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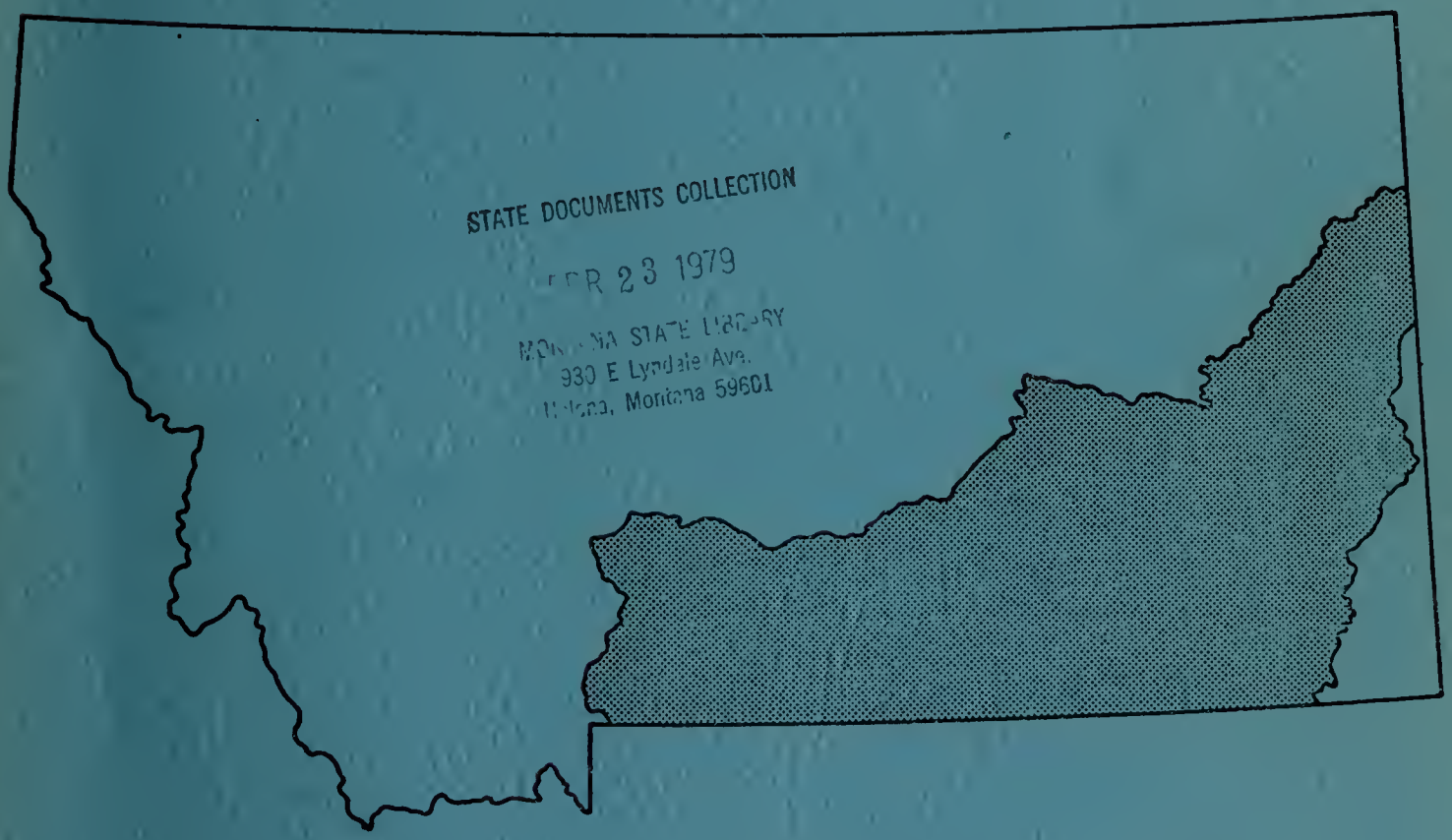
THE FUTURE OF YELLOWSTONE WATER



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WHICH WAY?

THE FUTURE OF YELLOWSTONE WATER

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October 1976

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MONTANA DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION

CONTENTS

		Page
FIGURES		iv
TABLES		v
ABBREVIATIONS USED IN THIS REPORT		vii
INTRODUCTION		1
PART I.	Water Resources of the Yellowstone River Basin	5
	Surface Water Resources	
	Ground Water Resources	
PART II.	Present and Projected Water Requirements for Consumptive Use	11
	Energy Water Use	
	Water Use for Irrigated Agriculture	
	Municipal Water Use	
	Other Consumptive Water Use	
	Water Availability for Projected Consumptive Use	
PART III.	The Impact of Increased Development on Instream Water Uses	35
	Channel Morphology	
	Water Quality	
	Fish and Wildlife	
	Recreation	
PART IV.	Water Rights	45
	Existing Water Rights	
	Indian Water Rights	
	Federal Water Rights	
	Existing Water Rights Litigation	
	Yellowstone River Compact	
PART V.	Resolving the Conflicts--The State Water Plan.	53
	Potential Solutions to Some Water Conflicts in the Yellowstone Basin	
	State Water Planning Programs	
SUMMARY		63
APPENDIXES		67
	Appendix A. Conversion Tables	
	Appendix B. Major Requests for the Appropriation or Reservation of Yellowstone Basin Water	

Appendix C. Methodology of the Irrigation Feasibility Study.
Appendix D. Municipal Water Use in the Yellowstone Basin.

LIST OF REFERENCES 79

FIGURES

		Page
1.	Average Monthly Flows of the Yellowstone River at Four Selected Stations.	7
2.	The Nine Planning Subbasins of the Yellowstone Basin	12
3.	Tongue River Subbasin Monthly Outflows at the Low Level of Development.	28
4.	Tongue River Subbasin Monthly Outflows at the Intermediate Level of Development	29
5.	Tongue River Subbasin Monthly Outflows at a Reduced High Level of Development	30
6.	Powder River Subbasin Monthly Outflows at the Low Level of Development	32
7.	Powder River Subbasin Monthly Outflows at a Reduced High Level of Development	33
8.	Lower Yellowstone Subbasin Monthly Outflows at the High Level of Development	34
9.	The Status of the Water Rights Adjudication Process in the Powder River Basin	47
10.	Preliminary Schedule for the Completion of the State Water Plan and Associated Studies	60

MAPS

	Follows Page
Strippable Coal Reserves	16
Potential Reservoir Sites and Major Industrial Water Applications	18
Irrigated and Irrigable Lands	20
Stream-Fishery Classification	42

TABLES

		Page
1.	Response by Montana Residents Polled to Statements about Coal Development	2
2.	Hydrologic Characteristics of Major Streams	8
3.	Yellowstone Basin Reservoirs with Total Capacities of 5,000 Acre-Feet or More	9
4.	Aquifer Characteristics	10
5.	Generating Capacity and Water Requirements for Thermal-Electric Plants in the Yellowstone Basin	14
6.	Hydroelectric Plants in the Yellowstone Basin	13
7.	The Projected Use of Coal Mined in 2000 in the Yellowstone Basin	16
8.	The Increase in Coal Conversion in the Yellowstone Basin in 2000	17
9.	The Increase in Water Depletion for Energy in 2000 by Subbasin	18
10.	Feasibly Irrigable Acreage by Lift and Pipeline Length, High Level of Development	21
11.	Feasibly Irrigable Acreage by County and Subbasin in 2000, High Level of Development.	23
12.	The Increase in Water Depletion for Irrigated Agriculture in 2000 by Subbasin	24
13.	The Increase in Water Depletion for Municipal Use in 2000	25
14.	The Increase in Water Depletion for Consumptive Use in 2000, by Subbasin.	26
15.	Estimated Indian Water Requirements by the Year 2020.	48
16.	Division of Waters Under the Yellowstone River Compact.	51
17.	Wyoming's Yellowstone Compact Estimates	51
18.	Storage and Cost Comparison of Selected Potential Yellowstone Basin Reservoirs.	56

Page

19. Water Requirements for Coal-Fired Electric Generating Plants 58

20. Increased Water Requirements for Consumptive Use in the Yellowstone Basin in 2000. 63

21. Increased Water Requirements for Coal Development in the Yellowstone Basin in 2000. 64

ABBREVIATIONS USED IN THIS REPORT

af	acre-feet
af/y	acre-feet per year
b/d	barrels per day
cfs	cubic feet per second
gpm	gallons per minute
mgd	million gallons per day
mg/l	milligrams per liter
mmaf	million acre-feet
mmaf/y	million acre-feet per year
mmcf/d	million cubic feet per day
mmt	million tons
mmt/y	million tons per year
mw	megawatts
SNG	substitute natural gas
t/d	tons per day
TDS	total dissolved solids
$/af/y	dollars per acre-foot per year

INTRODUCTION

It has now been five years since the publication of the North Central Power Study (North Central Power Study Coordinating Committee 1971), a product of the Bureau of Reclamation in cooperation with 35 major private and public electric power suppliers. The study identified 42 potential power plant sites in the five-state (Montana, North and South Dakota, Wyoming, and Colorado) northern Great Plains region, 21 of them in Montana. These plants, all fired by northern Great Plains coal, would generate 200,000 megawatts (mw) of electricity by 2000, consume 3.4 million acre-feet per year (mmaf/y) of water, and result in a population increase of from 50,000 to 1,000,000 people (Montana University Joint Water Resources Research Center 1975).

For many residents of Montana, that report was a confirmation of what had previously been an unpleasant, unsubstantiated belief: that massive development of eastern Montana's coal threatened to deplete the state's water resources, vastly increase our population, and irreparably alter a prized and envied way of life. Others welcomed it as a promise of economic boom. In either case, the passing of five years has brought substantial changes in the way most informed observers expect coal development to proceed in eastern Montana. Administrative, economic, legal, and technological delays have kept most of the conversion facilities projected by the North Central Power Study for 1980 on the drawing board or in the courtroom. There is now no chance of their being completed by that date or even soon after, which will delay and diminish the economic benefits some basin residents expected as a result of coal development. On the other hand, contracts have been signed for the mining of large amounts of Montana coal and applications approved for new and expanded coal mines and for Colstrip Units 3 and 4, twin 700-mw, coal-fired, electric generating plants.

One of the first manifestations of Montana's concern that there will not be enough water in the basin for all anticipated uses and that existing patterns of water use may suffer was the passage of significant legislation. The Water Use Act of 1973, which, among other things, mandates the adjudication of all existing water rights and makes possible the reservation of water for future beneficial use, was followed by the Water Moratorium Act of 1974, which delayed action on major applications for Yellowstone Basin water for three years. A wealth of Yellowstone water studies were undertaken at the state and federal levels.

Early in 1975, the Montana Department of Natural Resources and Conservation (DNRC) published the Yellowstone River Basin Water Resources Situation Report. In May of that year, the DNRC conducted a series of meetings in eight Yellowstone Basin cities (Sidney, Glendive, Miles City, Broadus, Forsyth, Hardin, Billings, and Livingston) to present the information contained in the Situation Report and record public sentiment about water planning and water conflicts. In almost

every city, the possibility of lower flows in the Yellowstone as a result of increased development in the basin emerged as a primary concern. In many of the cities, participants worried:

1) that available water would go to industry rather than agriculture because industry can afford to pay more,

2) that lower flows in the Yellowstone and strip mining might adversely affect the supply of ground water,

3) that a request from the Montana Department of Fish and Game for the reservation of 7.1 mmaf/y of Yellowstone water for instream flows for fish and wildlife habitat was too high, and

4) that adjudication of water rights in the basin was proceeding too slowly, and major development might take place before existing rights are adequately protected by adjudication.

Some participants perceived the conflicting demand for water in the Yellowstone as competition between the energy companies and the agriculturalists, with the federal government on the side of the energy companies.

In a 1975 survey of public opinion on future water use in the Yellowstone Basin, concern was expressed that agriculture might be an unsuccessful competitor for water with energy, as shown in table 1.

TABLE 1

RESPONSE BY MONTANA RESIDENTS POLLED TO STATEMENTS ABOUT COAL DEVELOPMENT

Statement	Response, in percentage of valid responses		
	Agree	Disagree	Neutral
There is enough water to satisfy the needs of the coal industry and for expanding agriculture as well.	43.5	38.1	18.5
Water that is needed for crops will be used up by the coal development industry.	41.5	39.8	18.7
Transfer from agricultural water rights to industry should be allowed.	7.2	78.3	14.5

SOURCE: Montana University Joint Water Resources Research Center 1975.

Whether the mass depletions and irreconcilable conflicts apparently feared by some will ever occur is debatable; recent projections (those presented in this report, for example) have shown a future energy industry far less thirsty than the one projected in earlier attempts. There is every indication that, in the year 2000, irrigated agriculture will still be by far the largest consumptive water use in the basin. But the existing concern over allocation of Yellowstone water resulted not from projected increases in irrigation (or even from the large increases in irrigation accomplished since 1971), but from the projected use of water for energy.

And that concern is warranted. Even though there will apparently be enough water in the Yellowstone mainstem for all projected consumptive uses, water availability is already a problem in some tributaries, and the projected increases in depletion in those tributaries are major. When instream uses, such as the dilution of wastes and the provision of fish and wildlife habitat, are considered, there may be conflicts even on the mainstem. Although not all data are complete, this preliminary report documents many such conflicting demands for water in the Yellowstone Basin; they must be resolved, one way or another, and some of them soon.

The purpose of this report is to assist in that process by providing information and obtaining, at the earliest opportunity, the opinions of the public and of other agencies regarding alternative future levels of development and potential solutions to water use conflicts. By recording public comment at a series of meetings in the Yellowstone Basin and by tabulating the written response to a number of related questions (a questionnaire is attached as the last page of this report), the DNRC hopes to obtain guidance concerning desirable policy decisions and actions on the part of the state in pursuing solutions.

Following consideration of public comment, this report will be revised, reprinted with the addition of recommendations, and distributed to the Montana legislature early in 1977. Please assist in the formulation of those recommendations by filling out the attached questionnaire and submitting it, along with any other comments, to the DNRC by November 12, 1976.

PART I

WATER RESOURCES OF THE YELLOWSTONE RIVER BASIN

The Yellowstone River Basin includes much of northern Wyoming, southeastern Montana, and a small portion of western North Dakota. It is bounded by the Rocky Mountains on the west, the Missouri Basin on the north, the Little Missouri and Cheyenne basins on the east, and the Platte Basin on the south. The total drainage area, with a length of about 440 miles and a maximum width of 320 miles, encompasses 70,400 square miles. Wyoming contains 51% of the drainage basin; Montana, nearly 48%; and North Dakota, about 1%. Information presented in this report concerns the Montana portion of the basin.

SURFACE WATER RESOURCES

QUANTITY

The Yellowstone River originates in Wyoming and flows northeasterly through Montana. The primary source of Yellowstone Basin water is the snowpack that accumulates in the mountains during the winter. Surface runoff from this snow normally begins in April and reaches a peak in late May or early June. The average monthly flows that occur during this time are 5 to 10 times the average flows that occur in fall and winter months. This runoff is significantly reduced in late July, after which normal summer flows may be modified by diversions or summer rains. Figure 1 illustrates average monthly flows of the Yellowstone River at Livingston, Billings, Miles City, and Sidney.

The average annual flow of the Yellowstone River at Sidney is 8.8 mmaf/y, approximately 33% of which originates within Montana. Table 2 shows average, maximum, and minimum runoffs of the Yellowstone River and its tributaries.

In the plains region, critically low flows, approaching no flows in some streams, occasionally occur in the fall, causing serious water availability problems for irrigators and affecting fish and wildlife.

Seven reservoirs in the basin (table 3) have total capacities of 5,000 acre-feet or more. These reservoirs provide over 1.5 mmaf of water storage for agricultural, municipal, industrial, recreational, and flood-control purposes.

QUALITY

In the headwaters of the Yellowstone River Basin, water quality is almost always excellent, although there are site-specific, mining- and agriculture-related problems with erosion, sedimentation pH, and heavy metals. The cold-water trout fisheries of the headwaters and upper reaches are among the nation's finest.

As streams flow into the plains and merge, they commonly undergo a transition to a warm-water fishery resulting from the decrease in

Figure 1 AVERAGE MONTHLY FLOW OF THE YELLOWSTONE RIVER AT FOUR STATIONS

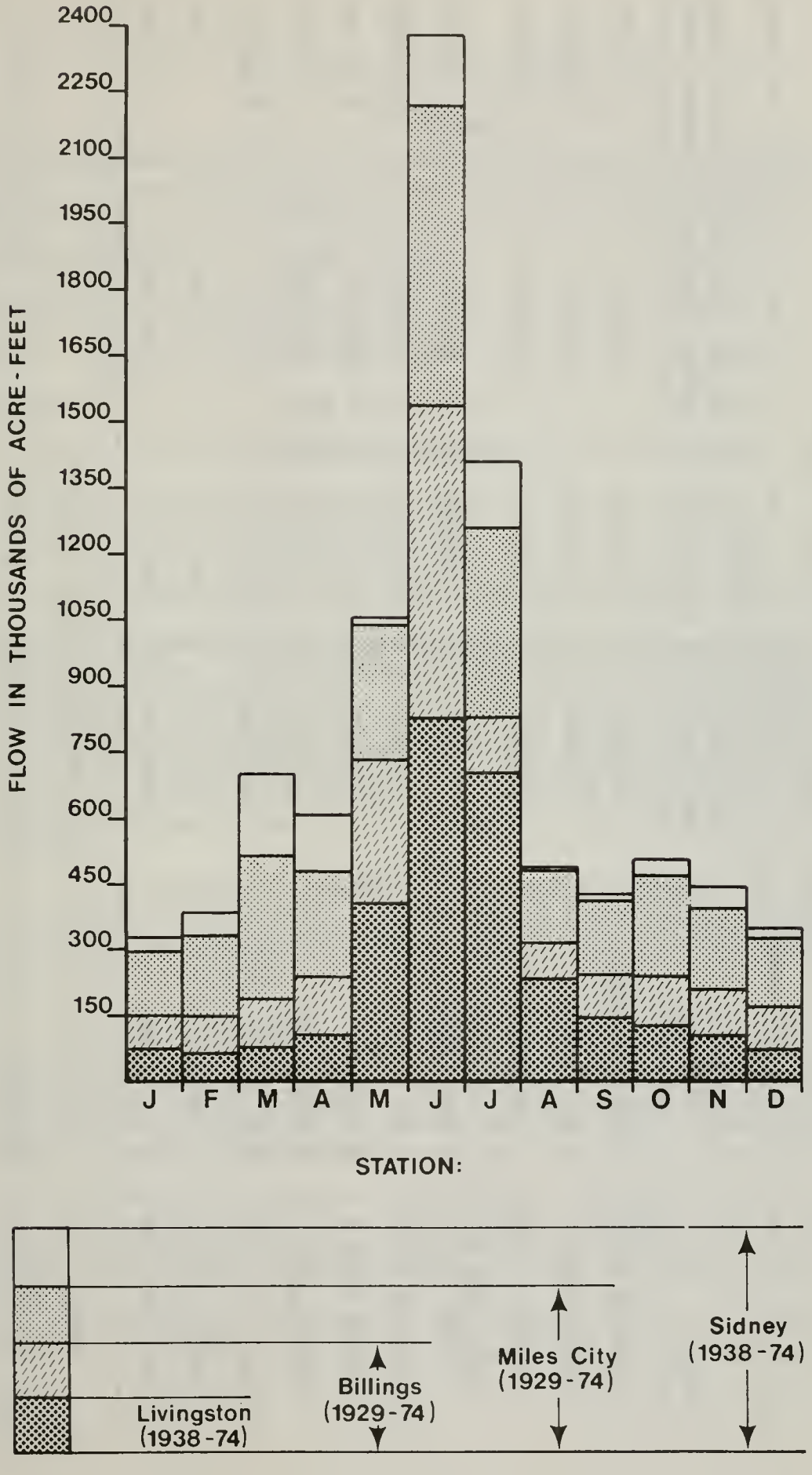


TABLE 2

HYDROLOGIC CHARACTERISTICS OF MAJOR STREAMS
(acre-feet)

Stream	Location of Station	Average Annual Runoff		Maximum Recorded Annual Runoff	Minimum Recorded Annual Runoff
		1970 Level of Development*	Historical**		
YELLOWSTONE RIVER	near Livingston	2,687,000	2,722,000	5,250,000	2,190,000
BOULDER RIVER	Big Timber	unknown	441,200	611,600	269,600
STILLWATER RIVER	near Absarokee	unknown	695,500	1,029,000	368,100
CLARKS FORK YELLOWSTONE RIVER	near Silesia	767,000	908,500	1,015,000	708,100
YELLOWSTONE RIVER	Billings	4,920,000	5,008,000	7,396,000	2,915,000
BIGHORN RIVER	Bighorn	2,550,000	2,828,000	3,967,000	1,175,000
TONGUE RIVER	Miles City	304,000	309,400	532,100	41,440
YELLOWSTONE RIVER	Miles City	8,102,000	8,274,000	12,060,000	4,446,000
POWDER RIVER	near Locate	416,000	446,300	1,178,000	57,500
YELLOWSTONE RIVER	near Sidney	8,800,000	9,420,000	13,800,000	4,073,000

SOURCES: NGPRP 1974 and unpublished, Montana DNRC unpublished, USDI 1974.

* 1970-level-of-development flows are averages calculated from historical records that have been modified to show the effects of 1970-level depletions in each year of study.

** The periods of record vary for these stations.

TABLE 3

YELLOWSTONE BASIN RESERVOIRS WITH
TOTAL CAPACITIES OF 5,000 ACRE-FEET
OR MORE

Reservoir	Stream	Total Storage Capacity (acre-feet)
Yellowtail Reservoir	Bighorn River	1,375,000
Tongue River	Tongue River	69,439
Cooney	Red Lodge Creek	24,190
Willow Creek	Lodge Grass Creek	23,000
Mystic Lake	West Rosebud Creek	20,800
Lake Walvoord	Sweet Grass Creek	14,000
Lake Adam	Sweet Grass Creek	11,000

gradient and the increase in temperature and concentration of total dissolved solids. This transition is sometimes considered a degradation since the water becomes less suitable for domestic use and, eventually, unsuitable for the growth and propagation of salmonid fishes. However, the plains waters support a healthy, diverse, and increasingly popular warm-water fishery and an extensive irrigated agriculture. The general absence of municipal and industrial pollution is indicated by high dissolved oxygen concentrations and low fecal coliform (bacteria) counts.

The Clarks Fork Yellowstone and its plains tributaries exhibit poor-to-fair water quality. Total dissolved solids (TDS) and sediment concentrations are high due to the geology of the lower basin and to agricultural practices.

The Bighorn was once a major source of sedimentation in the Yellowstone mainstem. When the gates of Yellowtail dam were closed in 1965, the sediment load of the Bighorn was reduced as much as 80% and of the Yellowstone mainstem at Sidney up to 20%. TDS concentrations in the Bighorn usually exceed 500 milligrams per liter (mg/l), the recommended upper limit for drinking water.

The Tongue River Reservoir has likewise reduced the sediment load of the Tongue River, which now contributes a very small part of the sediment load of the Yellowstone mainstem. TDS concentrations in the Tongue often exceed the recommended upper limit for drinking water.

Of all the major tributaries, the Powder River has the poorest quality. The Powder contributes only about 5% of the Yellowstone's water

but nearly half of the sediment. TDS concentrations are often high enough that they would adversely affect the production of some irrigated crops.

Despite the poor-quality water of many of the plains tributaries, the Yellowstone mainstem maintains at least fair water quality throughout. Although the situation is undocumented, water quality seems to have improved in the reach immediately downstream from Billings in recent years; formerly, organic pollution from the city, from oil refineries, and from meat processing plants caused a serious depletion of the stream's dissolved oxygen. Downstream, at Sidney, TDS concentrations are less than the recommended upper limit for drinking water most of the year. The river's capacity to transport sediment is greater throughout its length than the sediment load; therefore, siltation of diversions and backwaters is seldom a problem.

GROUND WATER RESOURCES

While shallow alluvial aquifers are limited to the valleys of the Yellowstone River and its tributaries, deep aquifers (including sandstones and coals in the Fort Union Formation, sandstones in both the Fox Hills and Hell Creek formations, and limestones in the Madison Group) underlie much of the basin. The Fort Union and the Fox Hills-Hell Creek formations are important for providing small amounts of water for stock and domestic use. The highest potential for development of large, high-volume appropriations is found in the shallow alluvial systems and the limestones in the Madison Group. Quantity and quality of the ground water from these aquifers are extremely variable, as shown in table 4.

TABLE 4

AQUIFER CHARACTERISTICS

Aquifer	Depth from Surface (ft)	Yield (gpm)	TDS (mg/l)
Shallow	To 300	5 - 1,500	300 - 6,000
Madison Group	1,000 - 8,000	2 - 3,700	550 - 300,000

SOURCES: U.S. Department of the Interior 1972 and 1973, Rahn 1975

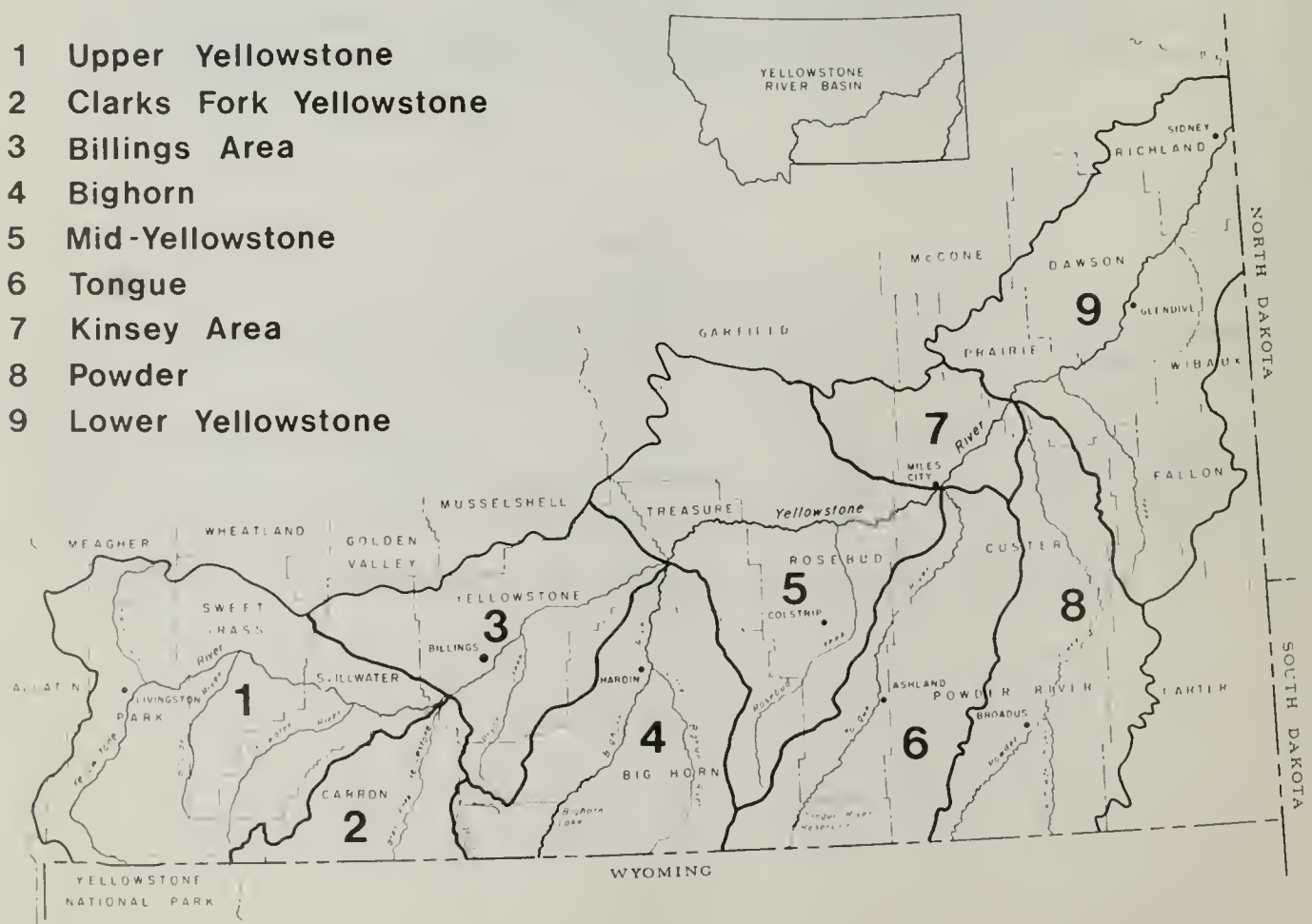
PART II

PRESENT AND PROJECTED WATER REQUIREMENTS FOR CONSUMPTIVE USE

This section discusses the present consumptive use of water (with emphasis on energy, irrigation, and municipal water use) and presents projections of future consumptive use. The projections consist of three future levels of development (low, intermediate, and high) projected by this Department in a current study of the physical, biological, and economic effects of water withdrawals from the Yellowstone River. The study is funded by the Old West Regional Commission, conducted by this Department, and is herein called the Yellowstone Impact Study. Significant portions of the study were performed by the Montana Department of Fish and Game and by the Water Quality Bureau of the Montana Department of Health and Environmental Sciences.

For each of the three levels of development, projections were organized geographically into nine subbasins within the Yellowstone Basin: Upper Yellowstone, Clarks Fork Yellowstone, Billings Area, Bighorn, Mid-Yellowstone, Tongue, Kinsey Area, Powder, and Lower Yellowstone. Those subbasins are delineated in figure 2.

Figure 2 **THE NINE PLANNING SUBBASINS OF THE YELLOWSTONE BASIN**



ENERGY WATER USE

PRESENT

The amount of water diverted for use in oil, coal, and gas production is relatively minor, and not all is actually consumed. Up to 173 million gallons per day (mgd) may be diverted for the cooling of thermal-electric plants that generate 1030 mw of electricity (table 5). Colstrip Units 3 and 4, which were certified by the Board of Natural Resources and Conservation, will each have a nameplate generation capacity of 700 mw and will each use 10,700 acre-feet of water per year. The on-line dates projected for the plants by the applicant utility companies is 1980 for unit 3 and 1981 for unit 4. Most of the water diverted for the four Colstrip units will be lost into the atmosphere during the cooling process. Other generating plants in the state consume less water because they utilize once-through cooling, a process that consumes very little water; the natural-gas-fired plant in Glendive uses dry cooling, which consumes even less.

The Yellowtail and Mystic Lake hydroelectric generating plants (table 6) produce 260 mw of power. While water used for hydroelectric generation is not consumed, reservoirs must be kept at certain levels for turbines to operate at maximum capacity, affecting water availability for downstream users. Water is consumed through evaporation from these reservoirs; however, it is difficult to determine how much of the evaporation loss should be apportioned to hydroelectric use since the reservoirs also serve other purposes.

TABLE 6

HYDROELECTRIC PLANTS IN THE YELLOWSTONE BASIN

Name	Water Source	Discharge (af/y)	Generating Capacity (mw)
Mystic	West Rosebud Creek	93,460	10
Yellowtail	Bighorn River	2,531,000	250

FUTURE

Energy Projection Methodology

Energy development in the Yellowstone River Basin in Montana will be affected by many factors, among them:

1) the availability of water for energy conversion processes,
2) the capacity of the rail system for coal export,
3) coal severance taxes,
4) the technology and economics of eastern coal desulfurization,
5) mined land reclamation requirements,
6) federal energy policy,
7) international politics,

TABLE 5

GENERATING CAPACITY AND WATER REQUIREMENTS
FOR THERMAL-ELECTRIC PLANTS IN
THE YELLOWSTONE BASIN*

Name	Location	Fuel	Nameplate Generating Capacity (mw)	Diversion Requirement (mgd)
Baker	Baker	Gas	1	neg.
Colstrip 1	Colstrip	Coal	350**	5***
Colstrip 2	Colstrip	Coal	350**	5***
Corette	Billings	Coal	180	82
Frank Bird	Billings	Oil	69	50
Glendive	Glendive	Gas	7	1
Miles City	Miles City	Gas	23	0
Sidney	Sidney	Coal	50	30
Total			1030	173

* Not shown are Colstrip Units 3 and 4, not yet constructed, which will have nameplate capacities of 700 mw each and will each require approximately 10 mgd of water, almost all of which will be consumed.

** Nameplate capacities of Colstrip Units 1 and 2 are 350 mw each; because of in-plant electrical requirements, only 330 mw can be delivered for transmission.

*** This approximate figure, derived from Montana DNRC 1974, includes some municipal water for the town of Colstrip. Almost all of this amount is lost to evaporation from the cooling towers during the cooling process; all other plants in this table use once-through cooling and consume very little of the amounts diverted.

8) federal and state legislation on slurry pipelines,
9) national growth in energy consumption, and
10) state policy on the allocation of water to various beneficial uses.

These factors interact in a complex way and are largely unpredictable, making projections of future demand for eastern Montana coal extremely difficult. The approach taken in projecting the energy development levels included here was to attempt to define the upper limit of coal development based on various assumptions regarding the effects of the many factors which will constrain the development. Projections and scenarios from other studies and programs such as the Northern Great Plains Resources Program (NGPRP 1975) were used as a starting point. These levels of development were then modified by incorporating more recent information, including the Montana University Coal Demand Study (Montana University Coal Demand Study Team 1976). Generally, the effect of these changes was to reduce the number of gasification plants included in the NGPRP's coal development profiles and to emphasize thermal-electric plants.

For coal production, the high level of development was based essentially on the NGPRP high projection, while the low level represented existing coal delivery contracts and known plans for new mines, with the intermediate level evenly spaced between the high and low.

The siting of mines and conversion plants was projected in subbasins depending on coal reserves, current mining, coal leases, and applications for industrial water.

It is essential that the state of Montana exert substantial control over the rate and scope of energy development. Thus, each level of development should be examined for its beneficial and adverse impacts so that Montana may, through the legislature, state agencies, and boards, pursue the appropriate energy development future.

Coal Development

In 1975, over 22 million tons of coal were mined in the state, up from 14 million in 1974, 11 million in 1973, and 1 million in 1969. By 1980, even if no new contracts are entered, Montana's annual coal production will exceed 40 million tons. Coal reserves (see "Strippable Coal Reserves" map following page 16), estimated at over 50 billion economically strippable tons (Montana Energy Advisory Council 1976), pose no serious constraint to the levels of development projected by the Yellowstone Impact Study (table 7), which range from 186.7 to 462.8 million tons stripped in the basin annually by the year 2000.

The Yellowstone Impact Study projections for coal conversion are shown in table 8 and the related water requirement illustrated in table 9. Unit water requirements used to derive water use from coal mining and conversion projections are shown in appendix A.

The "Potential Reservoir Sites and Major Industrial Water Applications" map following page 18 locates: 1) filings for industrial purposes made prior to passage in 1973 of the Montana Water Use Act, and 2) major applications for

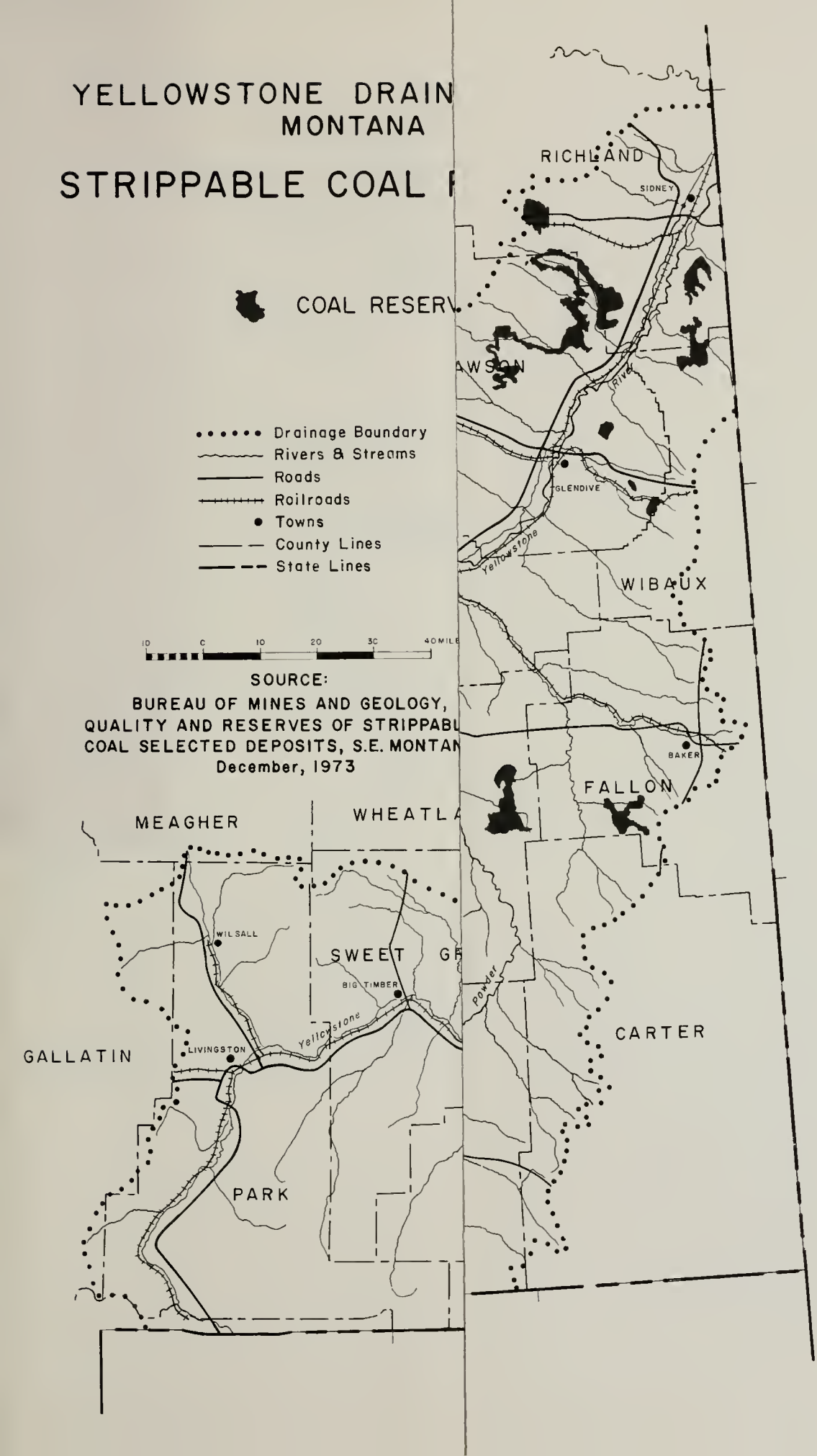
TABLE 7

THE PROJECTED USE OF COAL MINED IN 2000 IN THE YELLOWSTONE BASIN
(MILLIONS OF TONS PER YEAR)

Subbasin*	Electric Generation	Gasification	Syncrude	Fertilizer	Export **			Total
					Rail	Slurry	Total	
LOW LEVEL OF DEVELOPMENT								
Bighorn	0	0	0	0	17.1	0	17.1	17.1
Mid-Yellowstone	6.0	7.6	0	0	59.9	0	59.9	73.5
Tongue	2.0	0	0	0	77.0	0	77.0	79.0
Powder	0	0	0	0	17.1	0	17.1	17.1
Lower Yellowstone	0	0	0	0	0	0	0	0
Total	8.0	7.6	0	0	171.1	0	171.1	186.7
INTERMEDIATE LEVEL OF DEVELOPMENT								
Bighorn	0	0	0	0	23.4	5.9	29.3	29.3
Mid-Yellowstone	12.0	7.6	0	0	82.1	20.5	102.6	122.2
Tongue	8.0	0	0	0	105.6	26.4	132.0	140.0
Powder	4.0	0	0	0	23.4	5.9	29.3	33.3
Lower Yellowstone	0	0	0	0	0	0	0	0
Total	24.0	7.6	0	0	234.5	58.7	293.2	324.8
HIGH LEVEL OF DEVELOPMENT								
Bighorn	4.0	0	0	0	22.1	14.8	36.9	40.9
Mid-Yellowstone	12.0	15.2	18.0	0	77.3	51.6	128.9	174.1
Tongue	12.0	7.6	18.0	0	99.5	66.3	165.8	203.4
Powder	4.0	0	0	0	22.1	14.8	36.9	40.9
Lower Yellowstone	0	0	0	3.5	0	0	0	3.5
Total	32.0	22.8	36.0	3.5	221.0	147.5	368.5	462.8

* The four subbasins not shown (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area) do not include economically strippable coal deposits.

** It is assumed that, at the intermediate level of development, 20% of coal exports will be by slurry pipeline, and at the high level of development, 40%.


YELLOWSTONE DRAIN
MONTANA
STRIPPABLE COAL
COAL RESERV
Drainage Boundary
Rivers & Streams
Roads
Railroads
Towns
County Lines
State Lines
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SOURCE:
BUREAU OF MINES AND GEOLOGY,
QUALITY AND RESERVES OF STRIPPABL
COAL SELECTED DEPOSITS, S.E. MONTAN
December, 1973
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SIDNEY
GLENDIVE
Yellowstone
WIBAUX
BAKER
FALLON
CARTER
Powder
MEAGHER
WHEATL
WILSALL
SWEET G
BIG TIMBER
Yellowstone
LIVINGSTON
GALLATIN
PARK

YELLOWSTONE DRAINAGE BASIN
MONTANA

STRIPPABLE COAL RESERVES

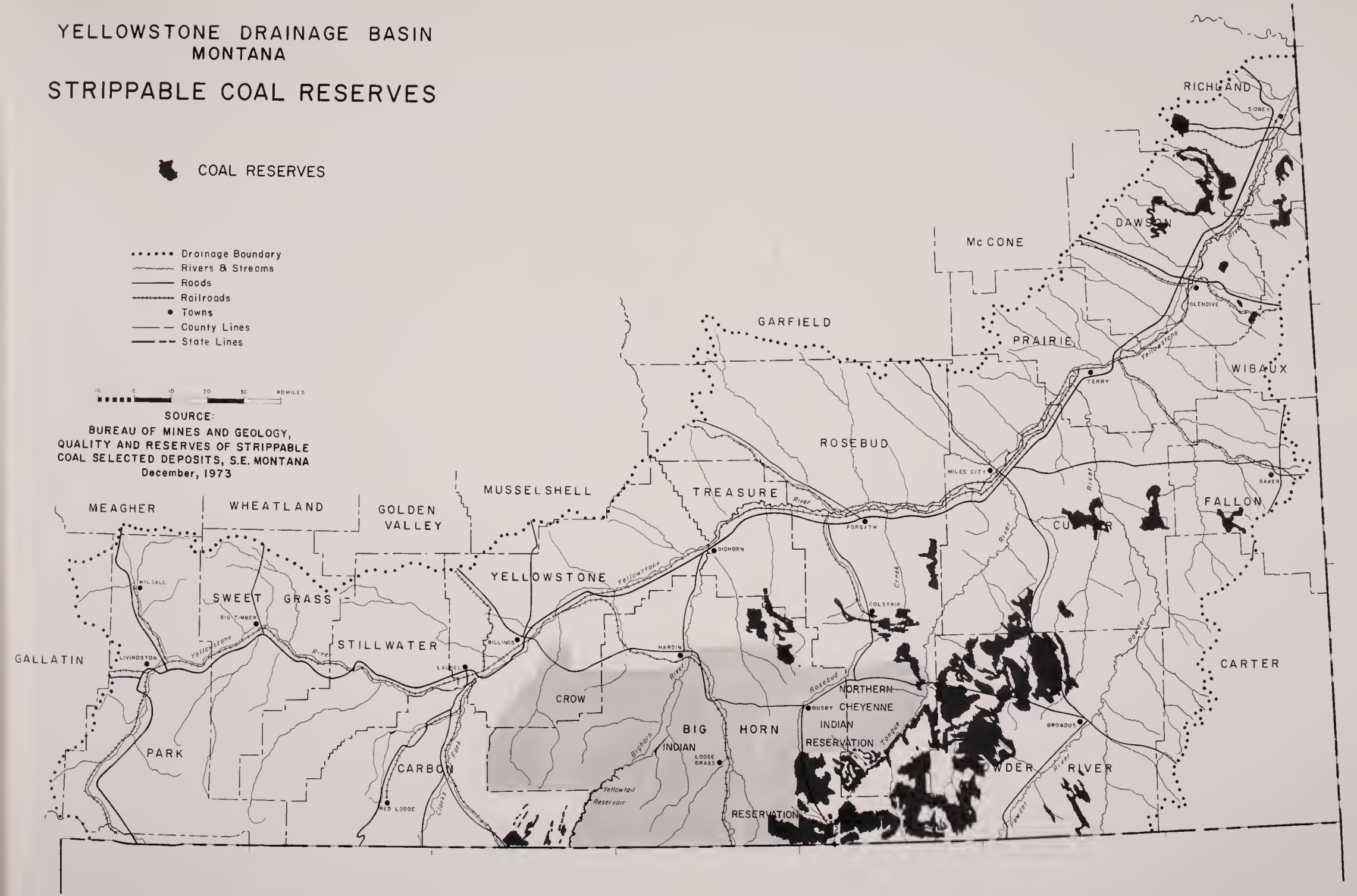


TABLE 8

THE INCREASE IN COAL CONVERSION IN THE YELLOWSTONE BASIN IN 2000

Subbasin*	Electric Generation (mw)	SNG (mmcf/d)	Syncrude (b/d)	Fertilizer (t/d)
LOW LEVEL OF DEVELOPMENT				
Bighorn	0	0	0	0
Mid-Yellowstone	1,500	250	0	0
Tongue	500	0	0	0
Powder	0	0	0	0
Lower Yellowstone	0	0	0	0
Total	2,000	250	0	0
INTERMEDIATE LEVEL OF DEVELOPMENT				
Bighorn	0	0	0	0
Mid-Yellowstone	3,000	250	0	0
Tongue	2,000	0	0	0
Powder	1,000	0	0	0
Lower Yellowstone	0	0	0	0
Total	6,000	250	0	0
HIGH LEVEL OF DEVELOPMENT				
Bighorn	1,000	0	0	0
Mid-Yellowstone	3,000	500	100,000	0
Tongue	3,000	250	100,000	0
Powder	1,000	0	0	0
Lower Yellowstone	0	0	0	2,300
Total	8,000	750	200,000	2,300

* The four subbasins not listed (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area) are not expected to include sites for coal conversion facilities.

TABLE 8

THE INCREASE IN COAL CONVERSION IN THE YELLOWSTONE BASIN IN 2000

Subbasin*	Electric Generation (mw)	SNG (mmcf/d)	Syncrude (b/d)	Fertilizer (t/d)
LOW LEVEL OF DEVELOPMENT				
Bighorn	0	0	0	0
Mid-Yellowstone	1,500	250	0	0
Tongue	500	0	0	0
Powder	0	0	0	0
Lower Yellowstone	0	0	0	0
Total	2,000	250	0	0
INTERMEDIATE LEVEL OF DEVELOPMENT				
Bighorn	0	0	0	0
Mid-Yellowstone	3,000	250	0	0
Tongue	2,000	0	0	0
Powder	1,000	0	0	0
Lower Yellowstone	0	0	0	0
Total	6,000	250	0	0
HIGH LEVEL OF DEVELOPMENT				
Bighorn	1,000	0	0	0
Mid-Yellowstone	3,000	500	100,000	0
Tongue	3,000	250	100,000	0
Powder	1,000	0	0	0
Lower Yellowstone	0	0	0	2,300
Total	8,000	750	200,000	2,300

* The four subbasins not listed (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area) are not expected to include sites for coal conversion facilities.

TABLE 9

THE INCREASE IN WATER DEPLETION FOR ENERGY IN 2000
BY SUBBASIN (af/y)

Subbasin*	INCREASE IN DEPLETION (af/y)						Total
	Elec. Generation	Gasifi-cation	Syn-crude	Ferti-lizer	Export	Strip Mining	
LOW LEVEL OF DEVELOPMENT							
Bighorn	0	0	0	0	0	860	860
Mid-Yellowstone	22,500	9,000	0	0	0	3,680	35,180
Tongue	7,500	0	0	0	0	3,950	11,450
Powder	0	0	0	0	0	860	860
Lower Yellowstone	0	0	0	0	0	0	0
Total	30,000	9,000				9,350	48,350
INTERMEDIATE LEVEL OF DEVELOPMENT							
Bighorn	0	0	0	0	4,420	1,470	5,890
Mid-Yellowstone	45,000	9,000	0	0	15,380	6,110	75,490
Tongue	30,000	0	0	0	9,900	7,000	46,900
Powder	15,000	0	0	0	2,210	1,670	18,880
Lower Yellowstone	0	0	0	0	0	0	0
Total	90,000	9,000			31,910	16,250	147,160
HIGH LEVEL OF DEVELOPMENT							
Bighorn	15,000	0	0	0	11,100	2,050	28,150
Mid-Yellowstone	45,000	18,000	29,000	0	38,700	8,710	139,410
Tongue	45,000	9,000	29,000	0	24,860	10,170	118,030
Powder	15,000	0	0	0	11,100	2,050	28,150
Lower Yellowstone	0	0	0	13,000	0	0	13,000
Total	120,000	27,000	58,000	13,000	80,210	22,980	326,740

* The four subbasins not shown (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area) are not expected to experience water depletion associated with coal development.

MAJOR INVESTIGATOR AND/OR INDUSTRIAL APPLICANT		RESERVOIR	CAPACITY (acre-feet)
Basin Electric		*	
Bureau of Reclamation	1	Allenspur	4,000,000
	2	Beehive	300,000
	6	Buffalo Creek	73,000
	10	Cedar Ridge	127,000
	8	Custer	825,000
	7	Lissa	2,180,000
	21	Moon Creek	150,000
	15	Moorhead	1,150,000
	25	Sunday Creek	678,000
	17	Sweeney Creek	116,000
	9	Tullock	270,000
Crow Tribe	11	Little Bighorn	70,000
	13	Owl Creek	8,000
	12	Pass Creek	14,000
	5	Pryor Creek	22,000
Getty Oil Co.	26	Thirteenmile Creek	32,000
Gulf Mineral Resources Co.	23	Coal Creek	29,480
	22	Lignite Creek	50,870
	20	Mizpah Creek	104,025
	18	Pump Creek	48,440
	19	Pumpkin Creek	103,410
Hunt Oil		*	
Intake Water Co.		**	
Mobil Oil Corporation		***	
Montana Department of Natural Resources and Conservation	14	New Tongue River	450,000
Montana Power Co. (3 filings)		*	
Montana Water Storage Co.	16	Lay Creek	130,000
Soil Conservation Service	4	Bluewater Creek	12,000
	3	Elbow Creek	11,700
Utah International Inc.		+	
Water Reserve Co.	24	Squaw Creek	91,000

NOTE: The linear symbols in red (+--, ⊢⊢, •••••) that precede the red location symbols for three of the applicant companies above represent the water conveyance systems (pipelines, canals, and drops) associated with those applications.

*These are filings submitted prior to the 1973 Water Use Act. No reservoirs are associated with them.

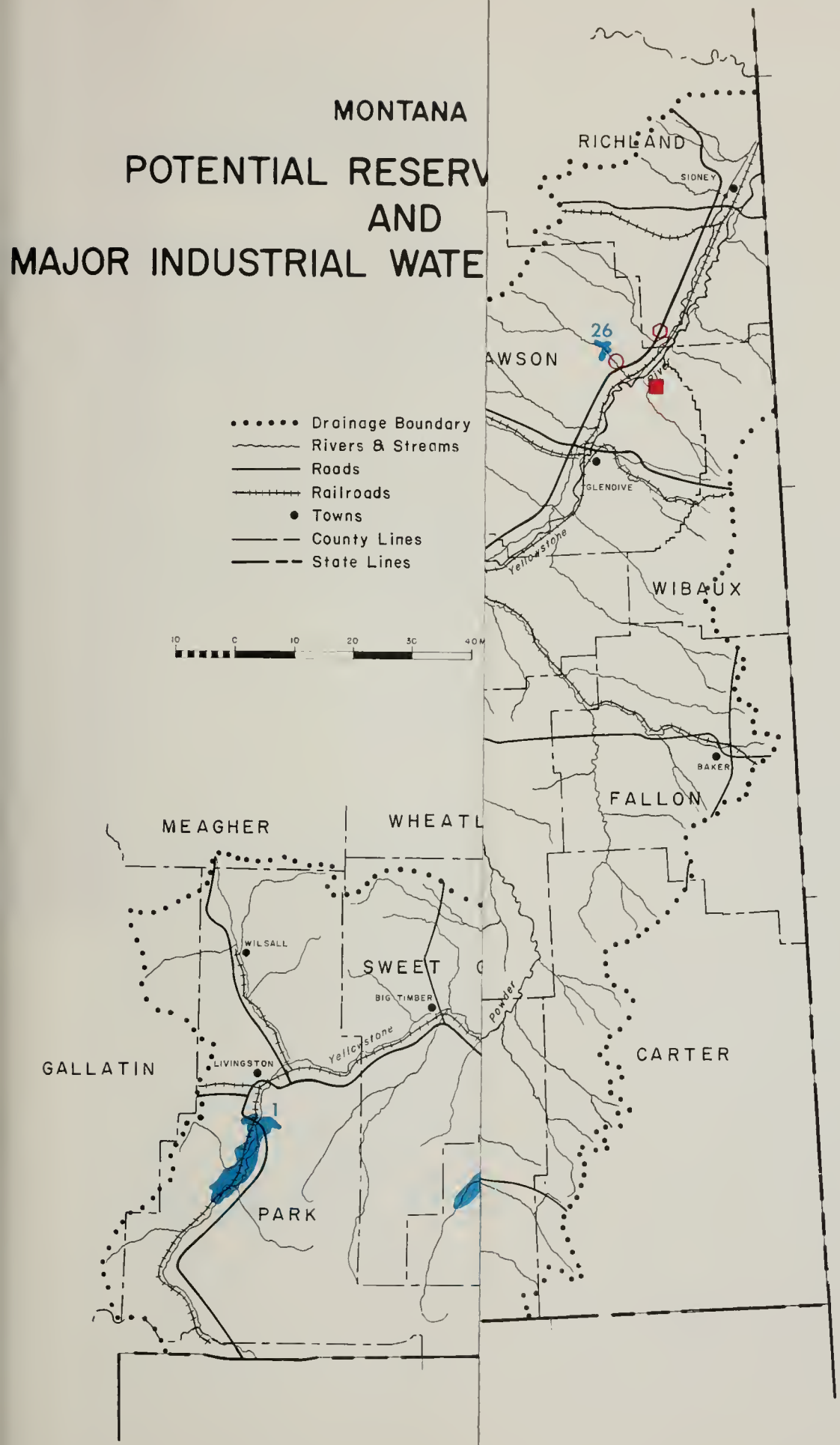
**Intake Water Company investigated a smaller reservoir (564,400 acre-foot capacity) at the Moorhead site (22). Intake also filed prior to the Water Use Act for use of 111 cfs from the lower Yellowstone (see map); that filing is under litigation.

***Mobil Oil Corporation investigated a larger reservoir (50,000 acre-foot capacity) at the Thirteenmile site (26).

+Utah International Inc. investigated a reservoir site (106,730 acre-foot capacity) on Fence Creek in Wyoming, intending use of that water in Montana.

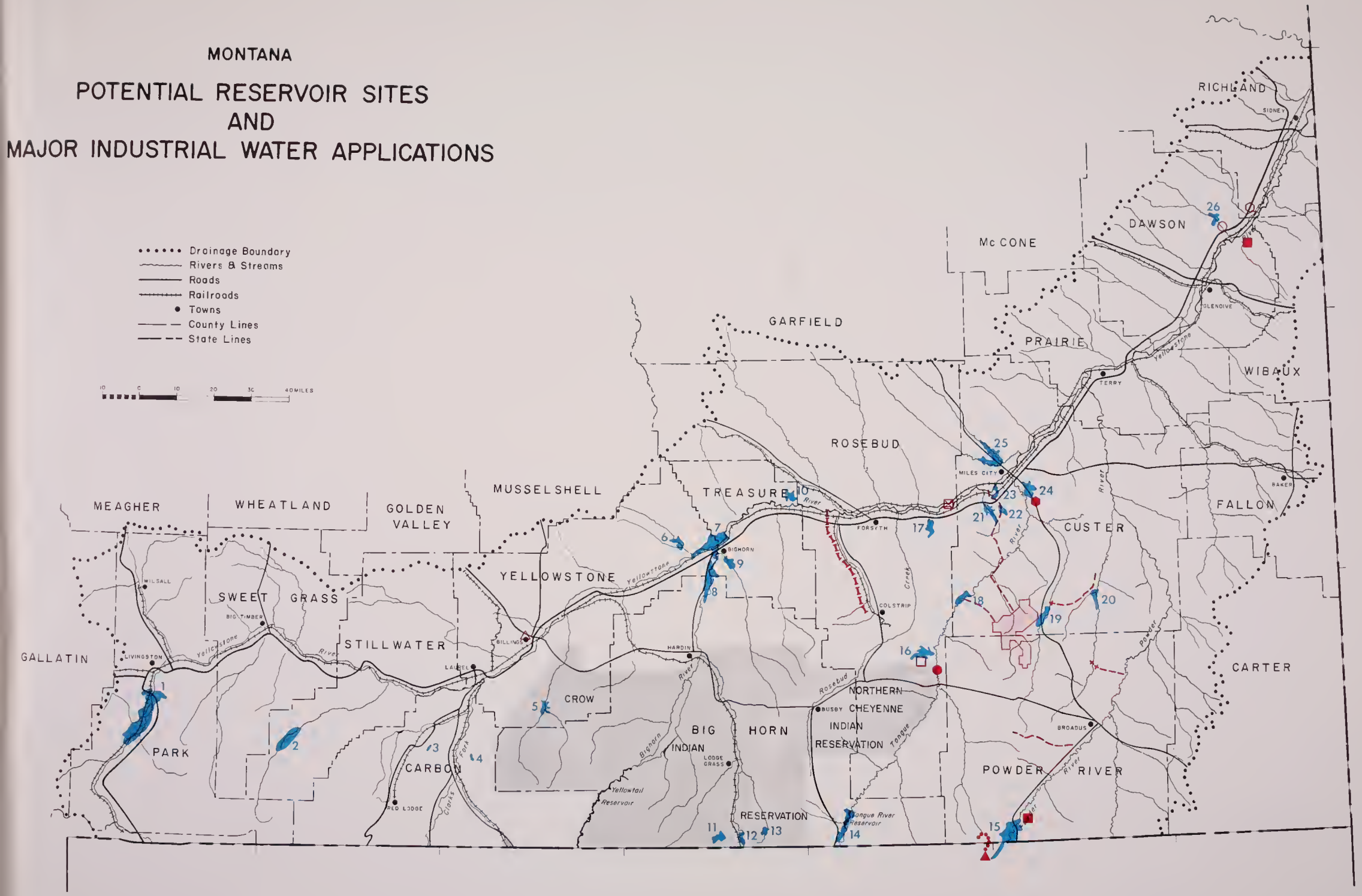
MONTANA

POTENTIAL RESERV
AND
MAJOR INDUSTRIAL WATE



MONTANA

POTENTIAL RESERVOIR SITES AND MAJOR INDUSTRIAL WATER APPLICATIONS



industrial purposes made following passage of the Act. The amounts of water filed or applied for are shown in detail in appendix B. Industrial companies have applied for much more water than will be required even assuming the highest projected level of coal development. In fact, they have applied in the Tongue and Powder river basins for more than is available, even through maximum storage.

Also shown on the "Potential Reservoir Sites and Major Industrial Water Applications" map are 26 potential reservoir sites investigated by energy companies in connection with their applications and filings and by federal and state agencies. For a variety of environmental and economic reasons, most of these sites will probably never be developed. The Allenspur site, for instance, was the subject of a joint resolution passed by the Montana legislature in 1974 declaring that construction of the dam would be contrary to state goals and objectives.

Hydroelectric Generation Potential

The potential for hydroelectric power generation in the basin is comparatively small. Even though the "Potential Reservoir Sites and Major Industrial Water Applications" map shows many reservoir sites, only the Allenspur and Lissa sites have been evaluated for hydroelectric potential; the Allenspur dam, if built, could provide 250 mw of power, and the Lissa dam, 85 mw.

WATER USE FOR IRRIGATED AGRICULTURE

THE PRESENT

Rainfall during the growing season, particularly in the eastern portion of the basin, rarely exceeds 10 inches. Since water requirements for most irrigated crops are normally over 20 inches during the entire growing season, irrigation of many crops is necessary. Lands in the basin which are now either fully or partially irrigated total about 777,000 acres and consume annually about 1.9 mmaf of water. This acreage figure is considerably higher than the 630,235 acres listed in the legend of the "Irrigated and Irrigable Lands" map following page 20. The higher figure is the most recent and includes information not available when the lower figure was calculated.

Irrigated agriculture in the Yellowstone Basin has been increasing since 1971 (Montana DNRC 1975b). Much of this expansion can be attributed to the introduction of sprinkler irrigation systems. Results from a questionnaire sent to local Soil Conservation Service offices indicate that approximately two-thirds of all irrigation systems recently installed are sprinkler systems (Montana DNRC 1975b), with pump lifts varying from a few feet to 450 feet above the Yellowstone River.

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THE FUTURE

Most irrigated agricultural products are used in beef production, which is highly variable. The future of irrigation depends, therefore, on more than availability of our land and water resources. General economic conditions, federal import and export policies, farmer preference, and world eating habits will be influential.

Irrigation Feasibility

The DNRC is conducting studies to determine the feasibility of delivering water to irrigable lands in the Yellowstone Basin, and to project what development may occur in the next 25 years. Only the Yellowstone River and the four main tributaries (Clarks Fork, Bighorn, Tongue, and Powder) were considered as water sources.

DNRC's reconnaissance land classification survey was used to identify the irrigable land in the basin. A preliminary economic evaluation, conducted to set upper limits of pumping feasibility, limited the area of consideration to land no more than three miles from the river and no more than 450 feet above the water source. The total area considered was thus reduced from the 2.2 million irrigable acres listed in the land classification survey to 448,000 acres, which were categorized according to lift (50' increments) and pipeline length (half-mile increments). The study concluded that of the 448,000 acres studied, 237,000 are financially feasible for irrigation given the assumptions and constraints explained in appendix C. The 237,000 acres feasible for irrigation are identified by county in the legend of the "Irrigated and Irrigable Lands" map following page 20. Table 10 shows the feasibly irrigable acreage in each subbasin by lift and pipeline length, and table 11 shows the same acreage by subbasin and county.

Three levels of development were projected to allow for such factors as farmer preference and peer influence: the lowest includes one-third; the intermediate, two-thirds; and the highest, all of the feasibly irrigable acreage. These constant-interval levels permit interpolation of results to other possible situations.

The number of acres financially feasible for irrigation for each development level was converted to a projected water consumption by applying a water depletion rate of two acre-feet per acre. This rate was derived from average consumption requirements for basin crops with allowances for factors such as evaporation and leakage from distribution systems. Table 12 shows the increased irrigated acreage and associated water consumption for the low, medium, and high levels of development in each subbasin.

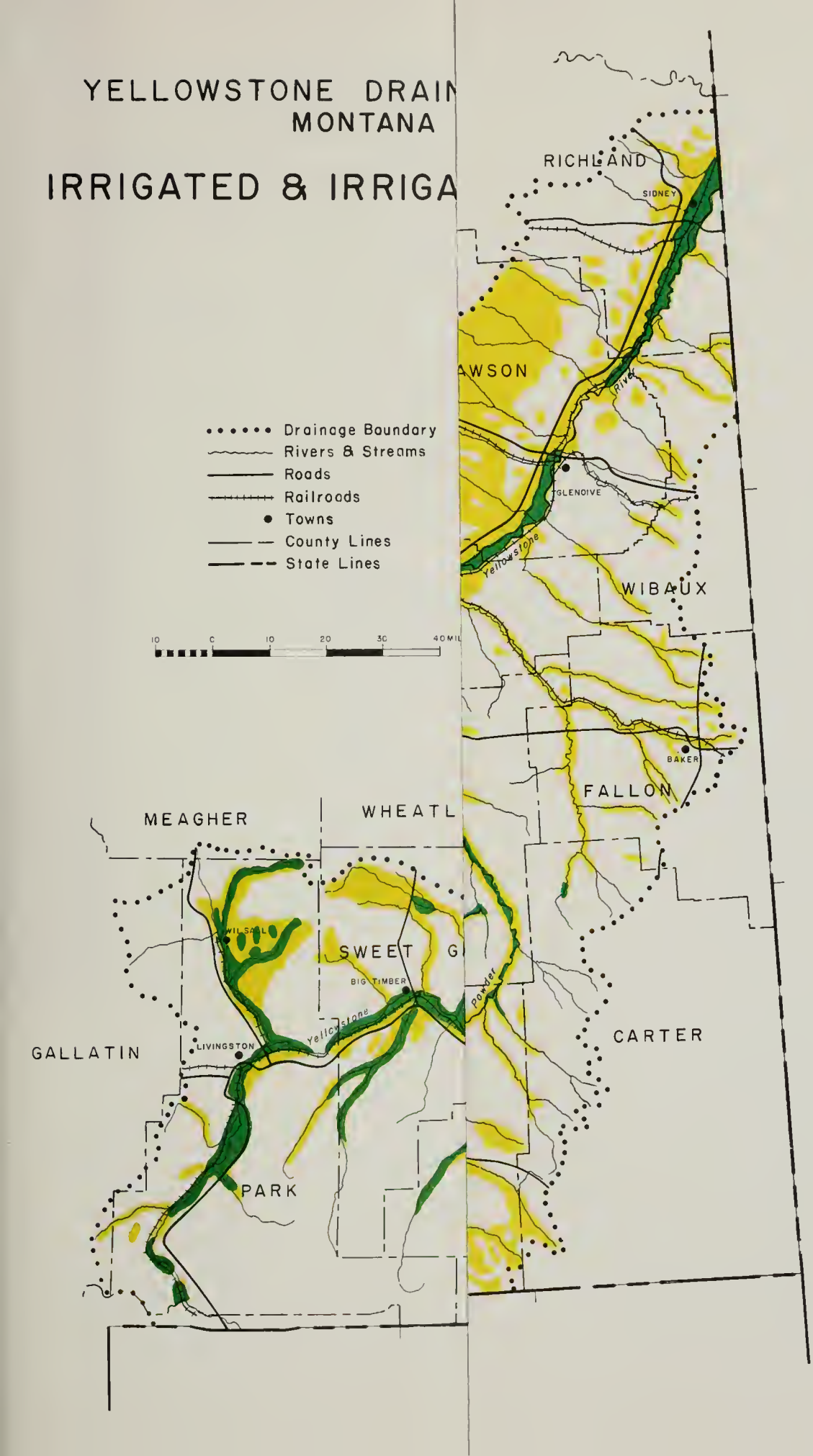
MUNICIPAL WATER USE

In 1970, 81% of the Yellowstone Basin's 168,300 people were served by municipal systems which used 28.9 mgd (32,900 af/y) of surface and ground water. That depletion is not significant compared to the 1.9 mmaf/y currently consumed by irrigated agriculture in the basin.

COUNTY	IRRIGATED LANDS	IRRIGABLE LANDS	LANDS FEASIBLE TO IRRIGATE * (not shown on map)
Big Horn	73,724	309,676	15,222
Carbon	96,363	70,509	2,160
Carter	2,185	12,108	**
Custer	42,244	88,272	43,795
Dawson	19,475	416,902	18,355
Fallon	2,433	48,399	**
Gallatin	4,220	4,180	**
Garfield	80	0	**
McCone	0	498	**
Meagher	25	121	**
Musselshell	102	674	**
Park	63,937	98,249	21,664
Powder River	33,339	394,486	46,853
Prairie	13,048	77,895	11,789
Richland	38,333	113,057	10,421
Rosebud	32,271	126,507	21,135
Stillwater	34,721	18,930	10,204
Sweetgrass	55,586	88,805	6,208
Treasure	21,231	82,504	9,591
Wibaux	107	18,489	663
Yellowstone	96,811	232,126	19,412
Basin total	630,235	2,202,387	237,472

*Criteria for feasibility are explained elsewhere in this report.

**Because only the Yellowstone mainstem and its major tributaries were considered as sources of irrigation water in the feasibility study discussed in this report, no lands in these counties were considered economically feasible to irrigate.


YELLOWSTONE DRAIN
MONTANA
IRRIGATED & IRRIGA
RICHLAND
SIDNEY
AWSON
River
GLENDIVE
Yellowstone
WIBAUX
BAKER
FALLON
MEAGHER
WHEATL
WILSALL
SWEET G
BIG TIMBER
Powder
Yellowstone
LIVINGSTON
GALLATIN
CARTER
PARK
Drainage Boundary
Rivers & Streams
Roads
Railroads
Towns
County Lines
State Lines
10 0 10 20 30 40 MIL

YELLOWSTONE DRAINAGE BASIN
MONTANA

IRRIGATED & IRRIGABLE LANDS

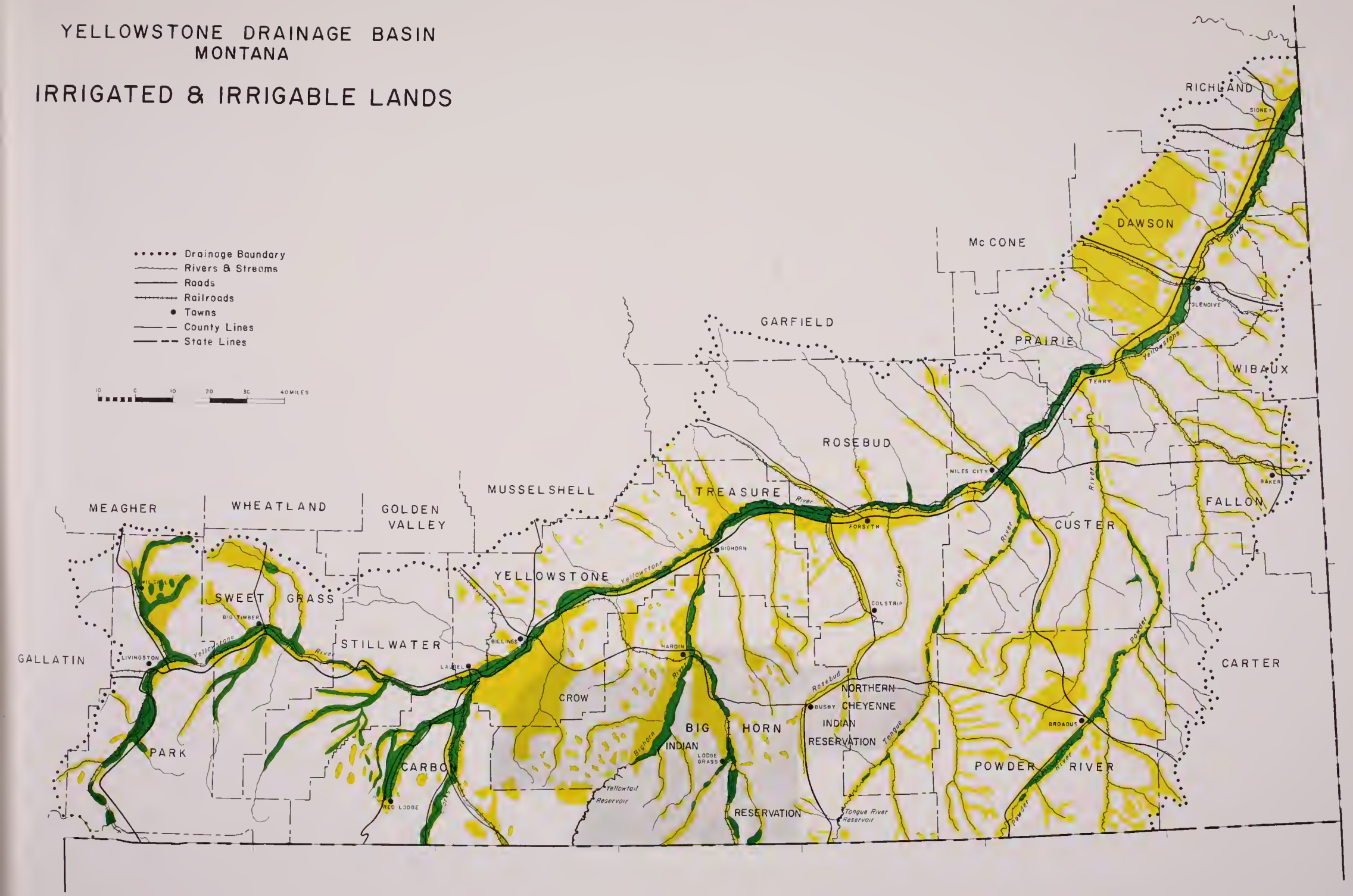


TABLE 10

FEASIBLY IRRIGABLE ACREAGE BY LIFT AND PIPELINE LENGTH,
HIGH LEVEL OF DEVELOPMENT

Pipeline length (mi)	Lift (ft) 0-50	50-100	100-150	150-200	200-250	250-300	Total
UPPER YELLOWSTONE SUBBASIN							
0 - .5	38,076	0	0	0	0	0	38,076
CLARKS FORK SUBBASIN							
0 - .5	2,160	0	0	0	0	0	2,160
BILLINGS AREA SUBBASIN							
0 - .5	3,308	3,324	329	2,147	0	222	9,330
.5 - 1.0	347	71	8,084	1,305	0	0	9,807
1.0 - 1.5	110	0	0	0	0	0	110
1.5 - 2.0	0	165	0	0	0	0	165
Total	3,765	3,560	8,413	3,452	0	222	19,412
BIGHORN SUBBASIN							
0 - .5	4,478	0	1,309	0	0	0	5,787
.5 - 1.0	1,608	3,451	0	0	0	0	5,059
1.0 - 1.5	0	2,191	0	0	0	0	2,191
Total	6,086	5,642	1,309	0	0	0	13,037
MID-YELLOWSTONE SUBBASIN							
0 - .5	16,000	1,691	0	0	0	0	17,691
.5 - 1.0	3,180	4,358	0	0	0	0	7,538
Total	19,180	6,049	0	0	0	0	25,229
TONGUE SUBBASIN							
0 - .5	21,947	0	0	0	0	0	21,947
KINSEY AREA SUBBASIN							
0 - .5	3,248	0	0	1,180	0	0	4,428
.5 - 1.0	0	0	0	0	0	0	0
1.0 - 1.5	308	0	0	0	0	0	308
Total	3,556	0	0	1,180	0	0	4,736
POWDER RIVER SUBBASIN							
0 - .5	74,224	0	0	0	0	0	74,224
.5 - 1.0	981	0	0	0	0	0	981
Total	75,205	0	0	0	0	0	75,205

TABLE 10

FEASIBLY IRRIGABLE ACREAGE BY LIFT AND PIPELINE LENGTH, HIGH LEVEL OF DEVELOPMENT

Pipeline length (mi)	Lift (ft) 0-50	50-100	100-150	150-200	200-250	250-300	Total
UPPER YELLOWSTONE SUBBASIN							
0 - .5	38,076	0	0	0	0	0	38,076
CLARKS FORK SUBBASIN							
0 - .5	2,160	0	0	0	0	0	2,160
BILLINGS AREA SUBBASIN							
0 - .5	3,308	3,324	329	2,147	0	222	9,330
.5 - 1.0	347	71	8,084	1,305	0	0	9,807
1.0 - 1.5	110	0	0	0	0	0	110
1.5 - 2.0	0	165	0	0	0	0	165
Total	3,765	3,560	8,413	3,452	0	222	19,412
BIGHORN SUBBASIN							
0 - .5	4,478	0	1,309	0	0	0	5,787
.5 - 1.0	1,608	3,451	0	0	0	0	5,059
1.0 - 1.5	0	2,191	0	0	0	0	2,191
Total	6,086	5,642	1,309	0	0	0	13,037
MID-YELLOWSTONE SUBBASIN							
0 - .5	16,000	1,691	0	0	0	0	17,691
.5 - 1.0	3,180	4,358	0	0	0	0	7,538
Total	19,180	6,049	0	0	0	0	25,229
TONGUE SUBBASIN							
0 - .5	21,947	0	0	0	0	0	21,947
KINSEY AREA SUBBASIN							
0 - .5	3,248	0	0	1,180	0	0	4,428
.5 - 1.0	0	0	0	0	0	0	0
1.0 - 1.5	308	0	0	0	0	0	308
Total	3,556	0	0	1,180	0	0	4,736
POWDER RIVER SUBBASIN							
0 - .5	74,224	0	0	0	0	0	74,224
.5 - 1.0	981	0	0	0	0	0	981
Total	75,205	0	0	0	0	0	75,205

TABLE 10, continued

Pipeline length (mi)	Lift (ft) 0-50	50-100	100-150	150-200	200-250	250-300	Total
			LOWER YELLOWSTONE SUBBASIN				
0 - .5	23,677	1,804	1,775	0	0	0	27,256
.5 - 1.0	1,813	4,992	100	0	0	0	6,905
1.0 - 1.5	0	2,599	0	0	0	0	2,599
1.5 - 2.0	0	805	0	0	0	0	805
2.0 - 2.5	0	105	0	0	0	0	105
Total	25,490	10,305	1,875	0	0	0	37,670
			BASIN SUMMARY				
0 - .5	187,118	6,819	3,413	3,327	0	222	200,899
.5 - 1.0	7,929	12,872	8,184	1,305	0	0	30,290
1.0 - 1.5	418	4,790	0	0	0	0	5,208
1.5 - 2.0	0	970	0	0	0	0	970
2.0 - 2.5	0	105	0	0	0	0	105
Total	195,465	25,556	11,597	4,632	0	222	237,472

NOTE: This table should not be considered an exhaustive listing of all feasibly irrigable acreage in the Yellowstone Basin; it includes only the acreage identified as feasibly irrigable according to the geographic and economic constraints explained elsewhere in this report.

TABLE 11

FEASIBLY IRRIGABLE ACREAGE BY COUNTY AND SUBBASIN IN 2000, HIGH LEVEL OF DEVELOPMENT

County	Upper Yellowstone	Clarks Fork	Billings Area	Big Horn	Mid Yellowstone	Tongue River	Kinsey Area	Powder River	Lower Yellowstone	County Totals
Park	21,664									21,664
Sweet Grass	6,208									6,208
Stillwater	10,204									10,204
Carbon		2,160								2,160
Yellow-stone			19,412							19,412
Big Horn				13,037		2,185				15,222
Treasure					9,591					9,591
Rosebud					11,408	9,727				21,135
Powder River								46,853		46,853
Custer					4,230	10,035	3,092	26,438		43,795
Prairie							1,644	1,914	8,231	11,789
Dawson									18,355	18,355
Richland									10,421	10,421
Wibaux									633	633
Basin Totals	38,076	2,160	19,412	13,037	25,229	21,947	4,736	75,205	37,670	237,472

NOTE: The number of irrigable acres for the low and intermediate development levels are one-third and two-thirds, respectively, of the numbers given here. This table should not be considered an exhaustive listing of all feasibly irrigable acreage in the Yellowstone Basin; it includes only the acreage identified as feasibly irrigable according to the geographic and economic constraints explained elsewhere in this report.

TABLE 12

THE INCREASE IN WATER DEPLETION FOR
IRRIGATED AGRICULTURE IN 2000
BY SUBBASIN

Subbasin	Acreage Increase	Increase in Depletion (af/y)
	LOW LEVEL OF DEVELOPMENT	
Upper Yellowstone	12,690	25,380
Clarks Fork	720	1,440
Billings Area	6,470	12,940
Bighorn	4,350	8,710
Mid-Yellowstone	8,410	16,820
Tongue	7,320	14,640
Kinsey Area	1,580	3,160
Powder	25,070	50,140
Lower Yellowstone	12,560	25,120
TOTAL	79,170	158,340
	INTERMEDIATE LEVEL OF DEVELOPMENT	
Upper Yellowstone	25,390	50,780
Clarks Fork	1,440	2,880
Billings Area	12,940	25,880
Bighorn	8,690	17,380
Mid-Yellowstone	16,820	33,640
Tongue	14,630	29,260
Kinsey Area	3,160	6,320
Powder	50,140	100,280
Lower Yellowstone	25,100	50,200
TOTAL	158,310	316,620
	HIGH LEVEL OF DEVELOPMENT	
Upper Yellowstone	38,080	76,160
Clarks Fork	2,160	4,320
Billings Area	19,410	38,820
Bighorn	13,040	26,080
Mid-Yellowstone	25,230	50,460
Tongue	21,950	43,900
Kinsey Area	4,740	9,480
Powder	75,200	150,400
Lower Yellowstone	37,670	75,340
TOTAL	237,480	474,960

The basin's projected population increase and associated municipal water use depletion for each level of development are shown in table 13. Even the 10,620 af/y depletion increase by 2000 shown for the highest development level is not significant compared to the projected depletion increases for irrigation or coal development. Nor is any problem anticipated in the availability of water to satisfy this increased municipal use. Many municipalities in the Yellowstone Basin utilize ground water and would presumably not experience shortages with any of the three development levels. Those using surface waters would likewise not experience shortages, since they are located high in the basin where there would be no energy diversions or on the mainstem where the supply is adequate. It is likely, however, that any municipal system serving an area which experiences a significant population increase would need to expand by providing new wells or pumps and constructing new storage, treatment, and distribution systems.

TABLE 13

THE INCREASE IN WATER DEPLETION FOR MUNICIPAL USE IN 2000

Level of Development	Population Increase	Increase in Depletion (af/y)
Low	56,858	5,880
Intermediate	62,940	6,960
High	94,150	10,620

Appendix D shows present and projected municipal water use by subbasin and details projected population increases in the basin.

OTHER CONSUMPTIVE WATER USES

There are a number of other consumptive water uses in Montana, including rural domestic, livestock, and nonenergy industrial uses. While these uses are vital, they consume only a small amount of water now and are not expected to require a significant amount of water at any time in the near future. Further information concerning these water uses can be found in Water Use in Montana, a report published as part of the State Water Plan (Montana DNRC 1975a).

WATER AVAILABILITY FOR PROJECTED CONSUMPTIVE USE

The average annual yield of the Yellowstone River Basin, at the 1970 level of development, is 8.8 mmaf. As shown in Table 14, the additional annual depletions required for the high level of development total about 812,000 acre-feet. Comparison of these two numbers might lead to the conclusion that there is ample water for such development, and more. That conclusion would be erroneous, however, because of the extreme variation of Yellowstone Basin streamflows from year to year, from month to month, and from place to place. At certain places and at certain times the water supply will be adequate in the foreseeable future. But in some of the tributaries

TABLE 14

THE INCREASE IN WATER DEPLETION FOR CONSUMPTIVE USE IN 2000, BY SUBBASIN

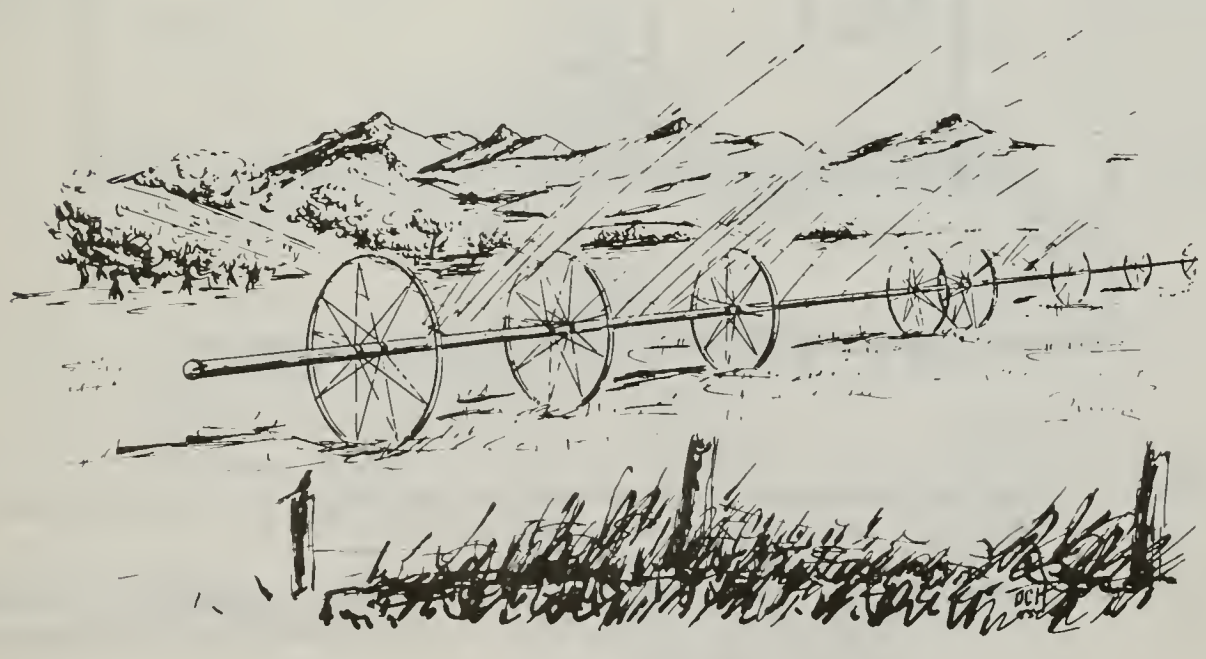
Subbasin	Increase in Depletion (af/y)			
	Irrigation	Energy	Municipal	Total
	LOW LEVEL OF DEVELOPMENT			
Upper Yellowstone	25,380	0	0	25,380
Clarks Fork	1,440	0	0	1,440
Billings Area	12,940	0	3,480	16,420
Bighorn	8,700	860	negligible	9,560
Mid-Yellowstone	16,820	35,180	1,680	53,680
Tongue	14,640	11,450	negligible	26,090
Kinsey Area	3,160	0	0	3,160
Powder	50,140	860	360	51,360
Lower Yellowstone	25,120	0	360	12,920
TOTAL	158,340	48,350	5,880	212,510
	INTERMEDIATE LEVEL OF DEVELOPMENT			
Upper Yellowstone	50,780	0	0	50,780
Clarks Fork	2,880	0	0	2,880
Billings Area	25,880	0	3,540	29,420
Bighorn	17,380	5,890	300	23,570
Mid-Yellowstone	33,640	75,490	1,860	110,990
Tongue	29,260	46,900	300	76,460
Kinsey Area	6,320	0	0	6,320
Powder	100,280	18,880	600	119,760
Lower Yellowstone	50,200	0	360	50,560
TOTAL	316,620	147,160	6,960	470,740
	HIGH LEVEL OF DEVELOPMENT			
Upper Yellowstone	76,160	0	0	76,160
Clarks Fork	4,320	0	0	4,320
Billings Area	38,820	0	3,900	42,720
Bighorn	26,080	28,150	480	54,710
Mid-Yellowstone	50,460	139,410	3,840	193,710
Tongue	43,900	118,030	780	162,710
Kinsey Area	9,480	0	0	9,480
Powder	150,400	28,150	1,140	179,690
Lower Yellowstone	75,340	13,000	480	88,820
TOTAL	474,960	326,740	10,620	812,320

and during low-flow times of many years, water availability problems, even under the low level of development, will be very real and sometimes very serious. In planning for additional agricultural or industrial developments, it is essential to know how much water is dependable for use, year after year.

This problem was addressed using the Montana State Water Planning Model, a computerized technique of simulating the monthly outflows from the nine planning subbasins. The model reports the monthly flow that the subbasin would have produced had each projected level of development been in effect during the previous years for which streamflow data are available.

A shortcoming of this procedure is that it cannot account for the allocation of waters to Montana and Wyoming under the terms of the Yellowstone Compact. It must be recognized that, especially for the Tongue and Powder subbasins, water that is shown to be hydrologically available in Montana may not be legally available once the issues surrounding the compact are resolved. In the absence of resolution of the compact issues, the Department's analysis assumed that water development in Wyoming would consume less water than Wyoming's compact share. The projections published in the Wyoming State Water Plan were assumed to be the best estimate of this water use.

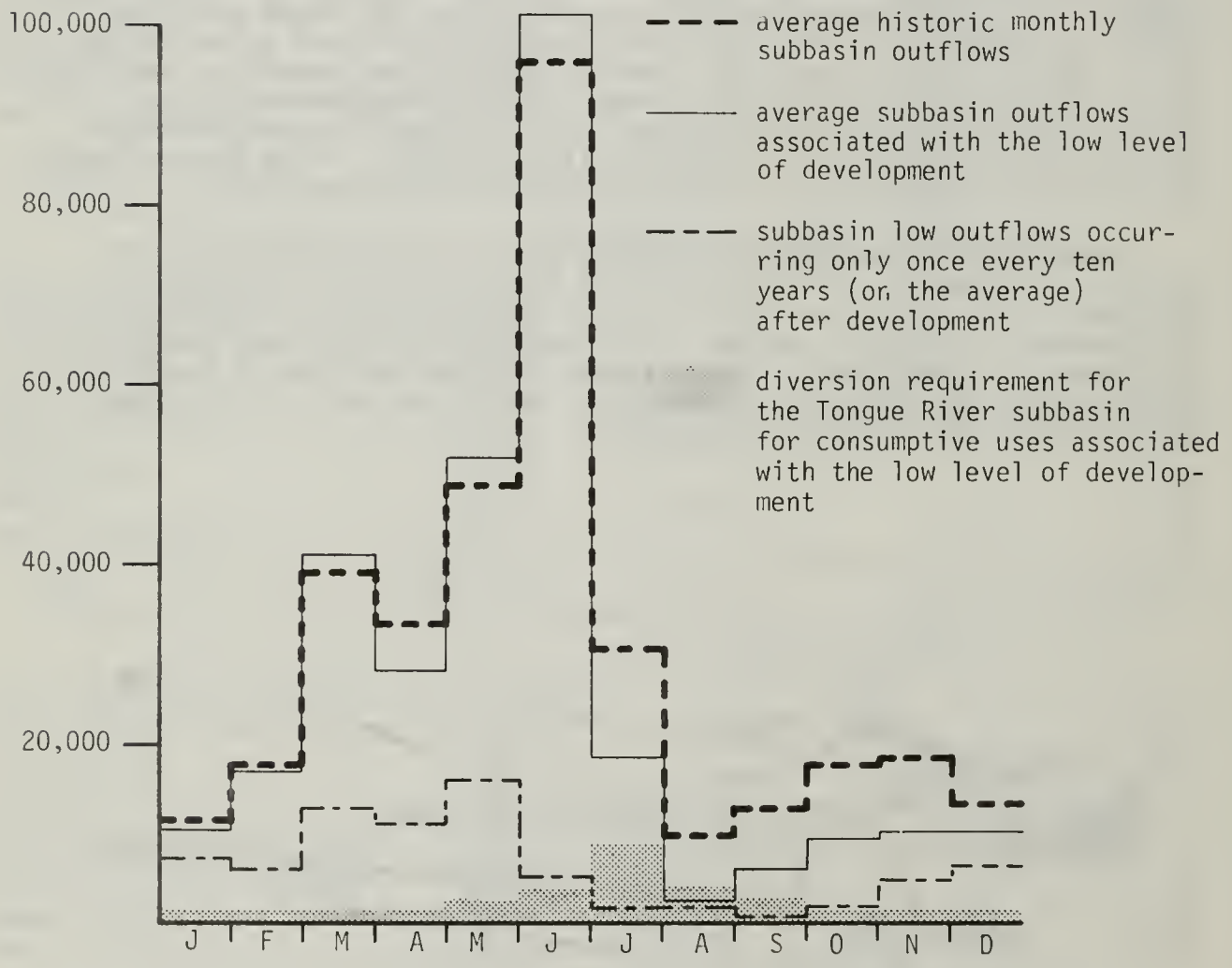
Because the Yellowstone Impact Study focused on the middle and lower portions of the basin, little is presented here and in other sections of this report with respect to the Clarks Fork Yellowstone and the Upper Yellowstone subbasins. However, because the projected agricultural and energy development is predominantly in the middle and lower portions of the basin, water availability problems and associated impacts (see part III) in these upper subbasins are expected to be slight.



TONGUE RIVER

Tongue River Reservoir, constructed in 1939, has an active storage of about 69,000 acre-feet and firm annual yield of 40,000 acre-feet, all of which is now obligated. There can be essentially no further development in the basin unless additional storage is provided.

Figure 3 shows a monthly hydrograph of outflows from the Tongue River Basin for the low level of development. Raising the existing dam to increase the active storage by 56,000 acre-feet would provide a total firm annual yield of about 73,000 acre-feet, which includes the 40,000 acre-feet currently contracted and used. This larger reservoir would also provide modest instream flows.

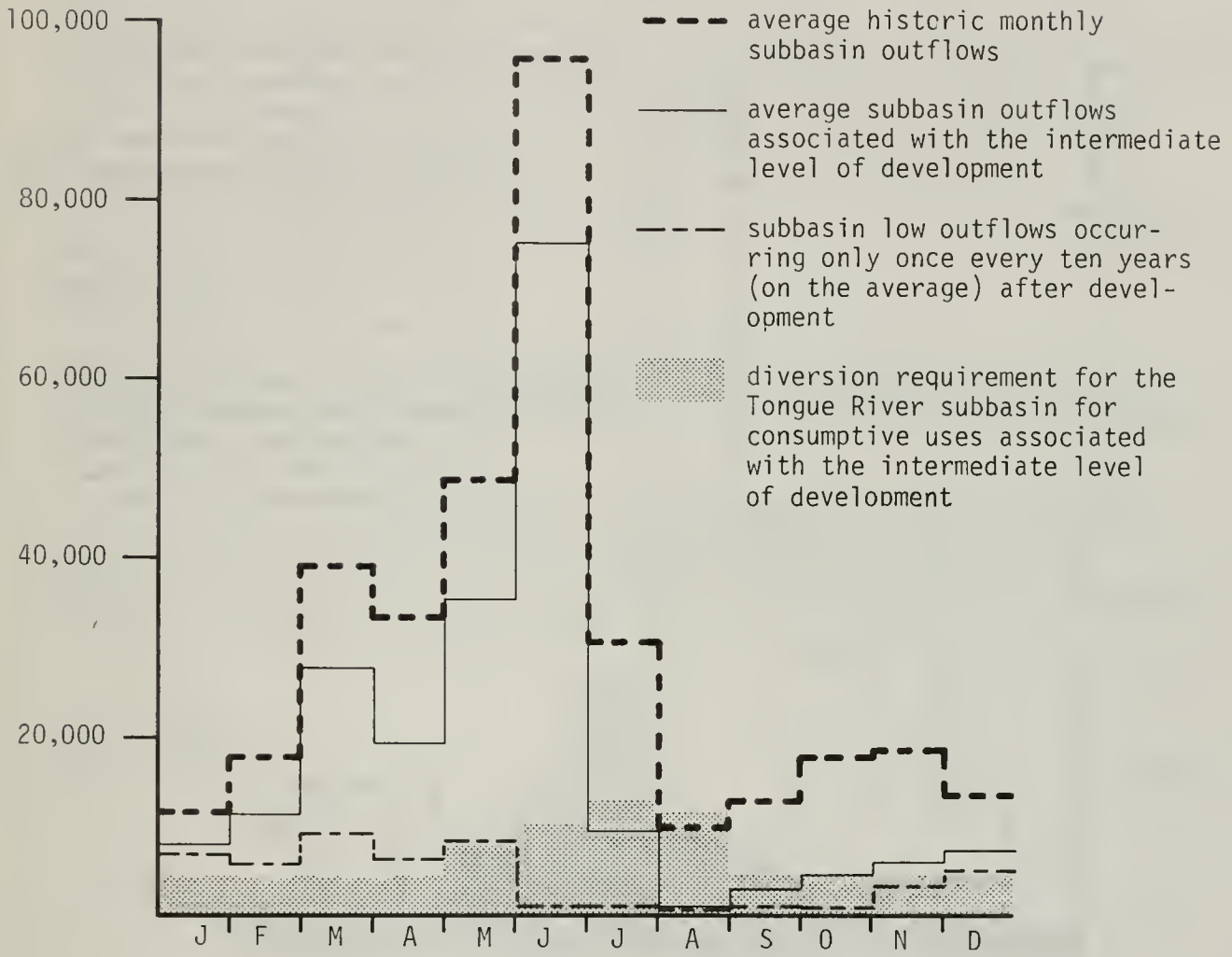


ASSUMPTIONS

Level of development: all of the projected low level of development
Reservoir active storage: 125,000 af
Subbasin firm annual yield: 73,000 af
Instream flows: up to 100% of the NGPRP (1974) recommended instream flows may be provided when inflow to the reservoir exceeds diversion demands.

Figure 3. Tongue River Subbasin Monthly Outflows at the Low Level of Development.

Figure 4 shows that a 320,000 acre-foot active storage reservoir could more than meet the diversion requirements associated with the intermediate level of development.

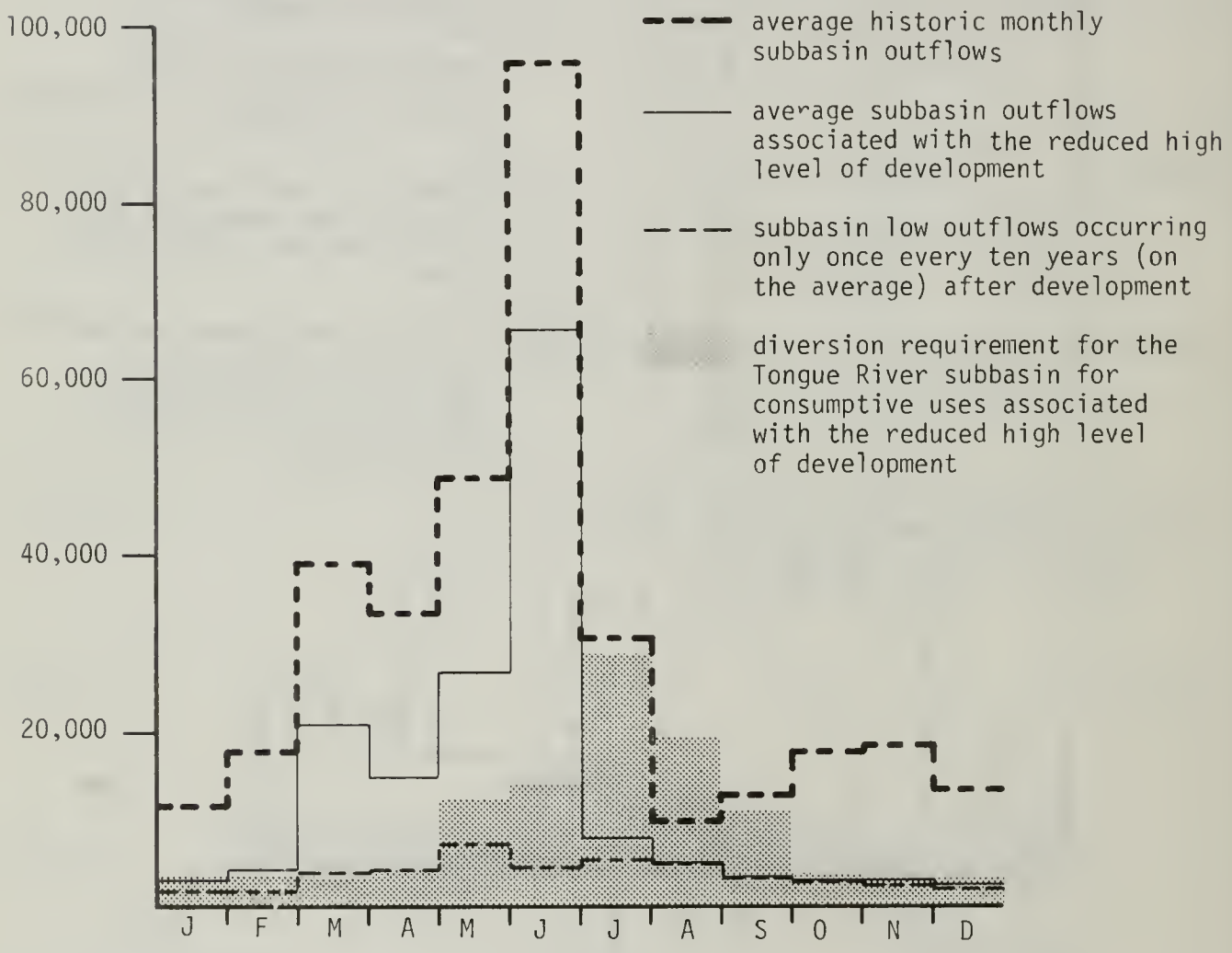


ASSUMPTIONS

Level of development: all of the projected intermediate level of development
Reservoir active storage: 320,000 af
Subbasin firm annual yield: 134,000 af
Instream flows: up to 60% of the NGPRP (1974) recommended instream flows may be provided when inflow to the reservoir exceeds diversion demands

Figure 4. Tongue River Subbasin Monthly Outflows at the Intermediate Level of Development.

With regard to the high level of development, Figure 5 shows the effect of a 320,000 acre-foot active storage reservoir. Water could be supplied to meet the irrigation demand and provide in-stream flows of 45 cfs during March, April, and May and 15 cfs the rest of the year. Enough water would be left to supply about 28% of the energy demand.



ASSUMPTIONS

Level of development: all of the projected high level of irrigation development and 28% of the projected high level of energy development
Reservoir active storage: 320,000 af
Subbasin firm annual yield: 134,000 af
Instream flows: flows of 45 cfs in March, April, and May and 15 cfs all other months.

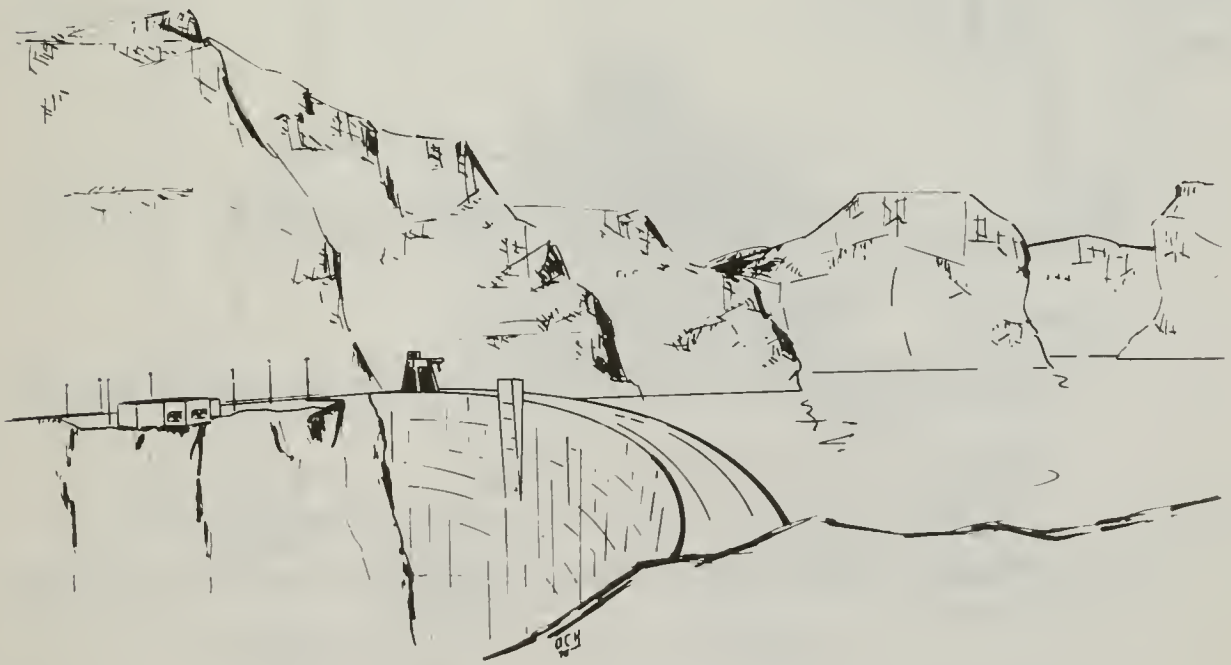
Figure 5. Tongue River Subbasin Monthly Outflows at the Reduced High Level of Development.

In a 1969 study, Bechtel Corporation analyzed the availability of water in the Tongue River Basin for allocation under the Yellowstone Compact's terms, one of which provides that Wyoming is entitled to supplemental water for lands partially irrigated prior to 1950. However, according to Bechtel, much of this irrigation will never be developed because of the high cost of delivering water to those lands. A "realistic" allocation was therefore developed based on a reasonable estimate for Wyoming supplemental irrigation water. The study considered a New Tongue River Reservoir, which would be located about 10 miles downstream from the existing dam. Stage I of this reservoir would have an active storage of 320,000 acre-feet and a firm annual yield of 100,000 acre-feet; Stage II would have an active storage of 450,000 acre-feet and a firm annual yield of 112,000 acre-feet. Stage I, considered because the reservoir would lie entirely within Montana, has the same capacity as the reservoir used in the Department's simulations of the intermediate and high levels of development discussed above. The difference in the firm annual yields is due to the difference in assumptions for Wyoming's supplemental irrigation water.

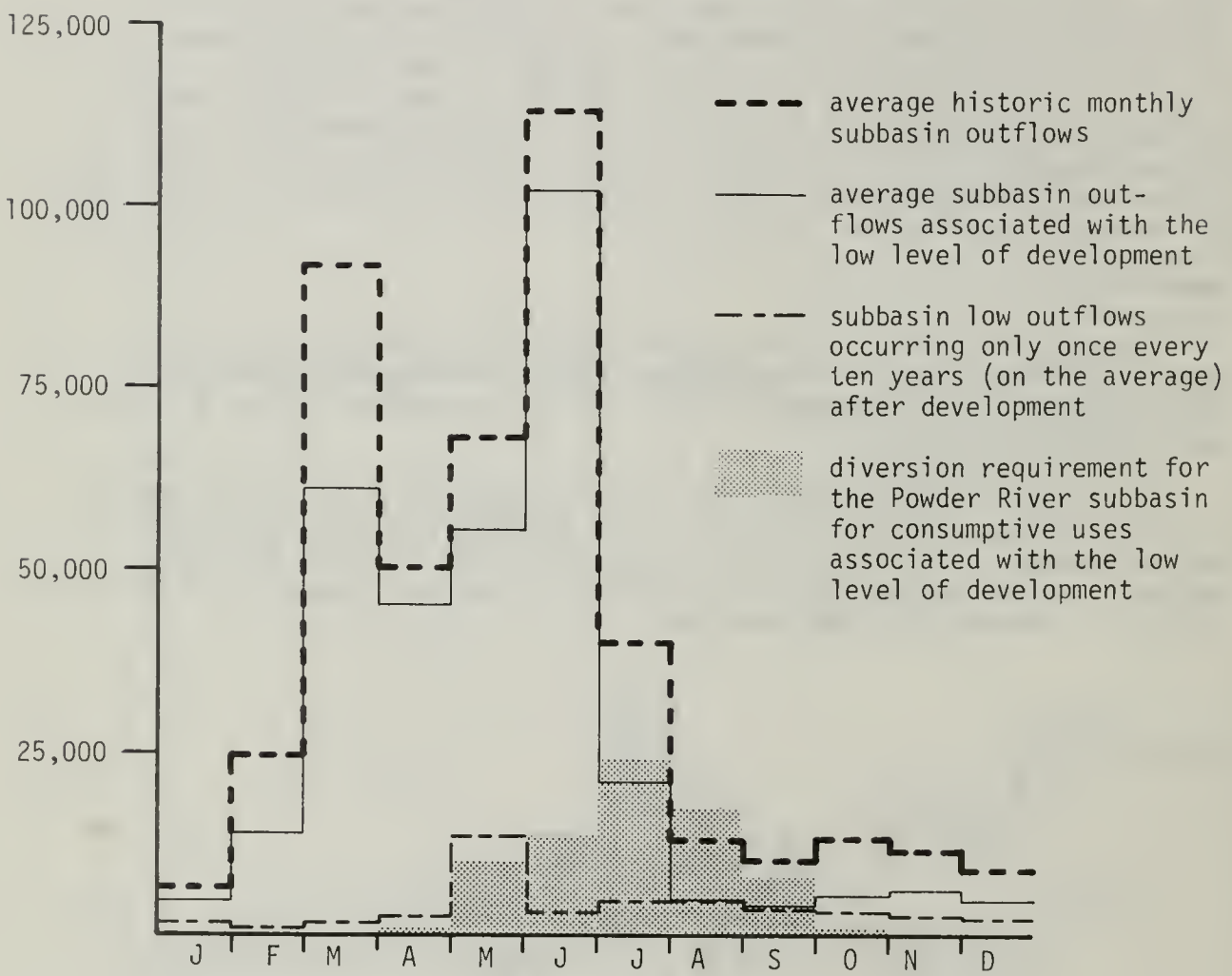
POWDER RIVER

Because there is no storage, water availability problems in the Powder River are acute. At the present level of development, there is no water available for a dependable supply for any substantial energy or agricultural development.

The proposed Moorhead Dam would initially provide an active storage of 835,000 acre-feet. During the life of the project, siltation would reduce active storage to 275,000 acre-feet, and that figure was used for this analysis. A firm annual yield of 124,000 acre-feet would be provided by an active storage of 275,000 acre-feet.



The monthly hydrograph of the Powder River, with Moorhead Dam, is shown in Figure 6 for the low level of development. The water supply is adequate, but instream flows are often minimal.



ASSUMPTIONS:

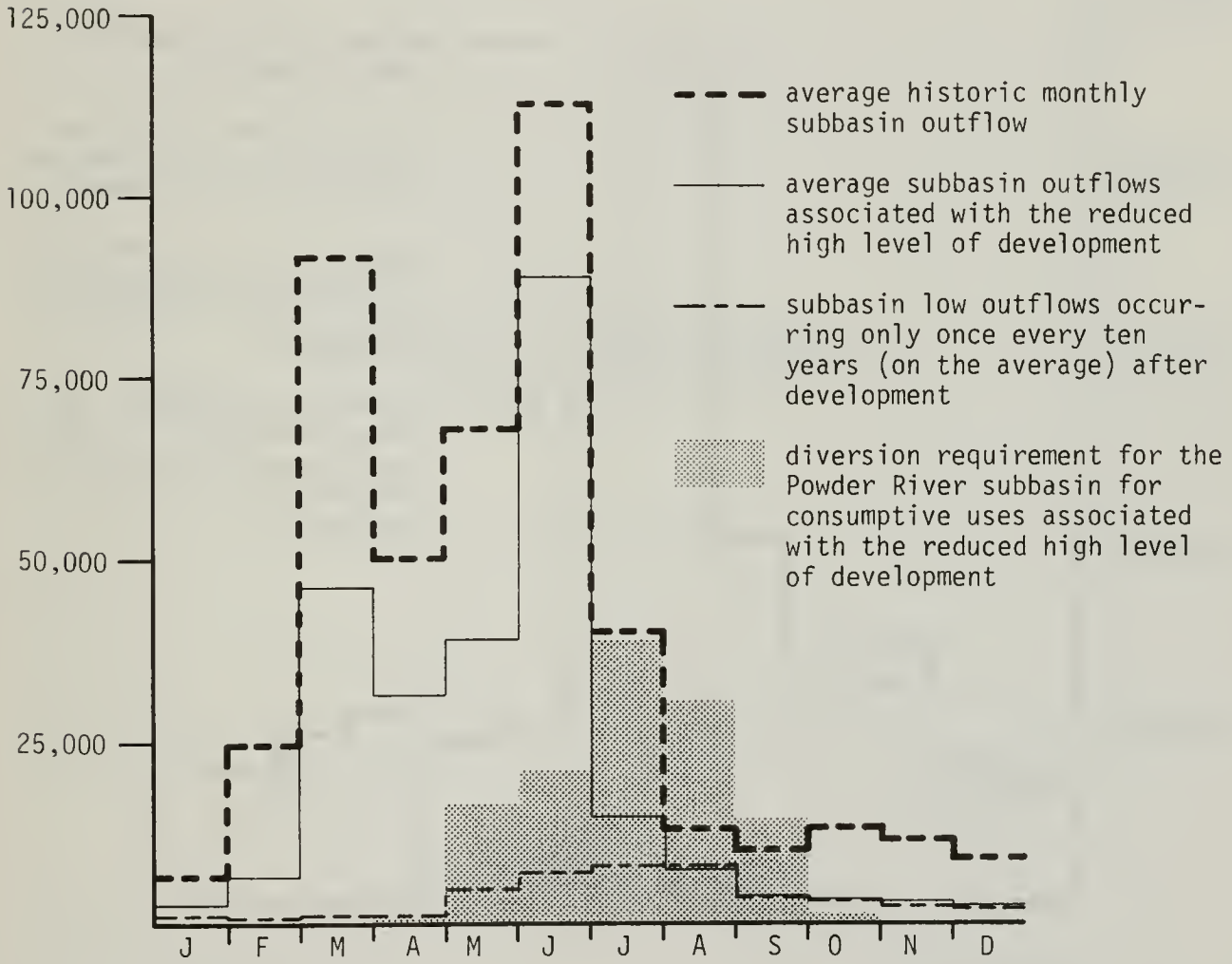
Level of Development: all of the projected low level of development
Reservoir active storage: 275,000 af
Subbasin firm annual yield: 124,000 af
Instream flows: no provisions are made for instream flows

Figure 6. Powder River Subbasin Monthly Outflows at the Low Level of Development.

Even with Moorhead Dam, the demands of the intermediate and high levels of development cannot be met in the Powder. Figure 7, for example, shows the monthly hydrograph for supplying 55 percent of the high irrigation development but no water for energy. Again, instream flows are minimal.

Two additional problems may constrain the level of development in the Powder River Basin. One is the degradation of water quality, discussed in Part III. The second is the likelihood that Moorhead Dam will be too expensive to justify its construction for irrigation development alone. It is therefore necessary to analyze combinations of purposes.

This Department is currently investigating different mixes of water for irrigation and energy requirements to determine the maximum amount of irrigation that can economically be developed, and the combination of water for energy and irrigation that maximizes economic return. That analysis should be complete by January 1977.



ASSUMPTIONS:

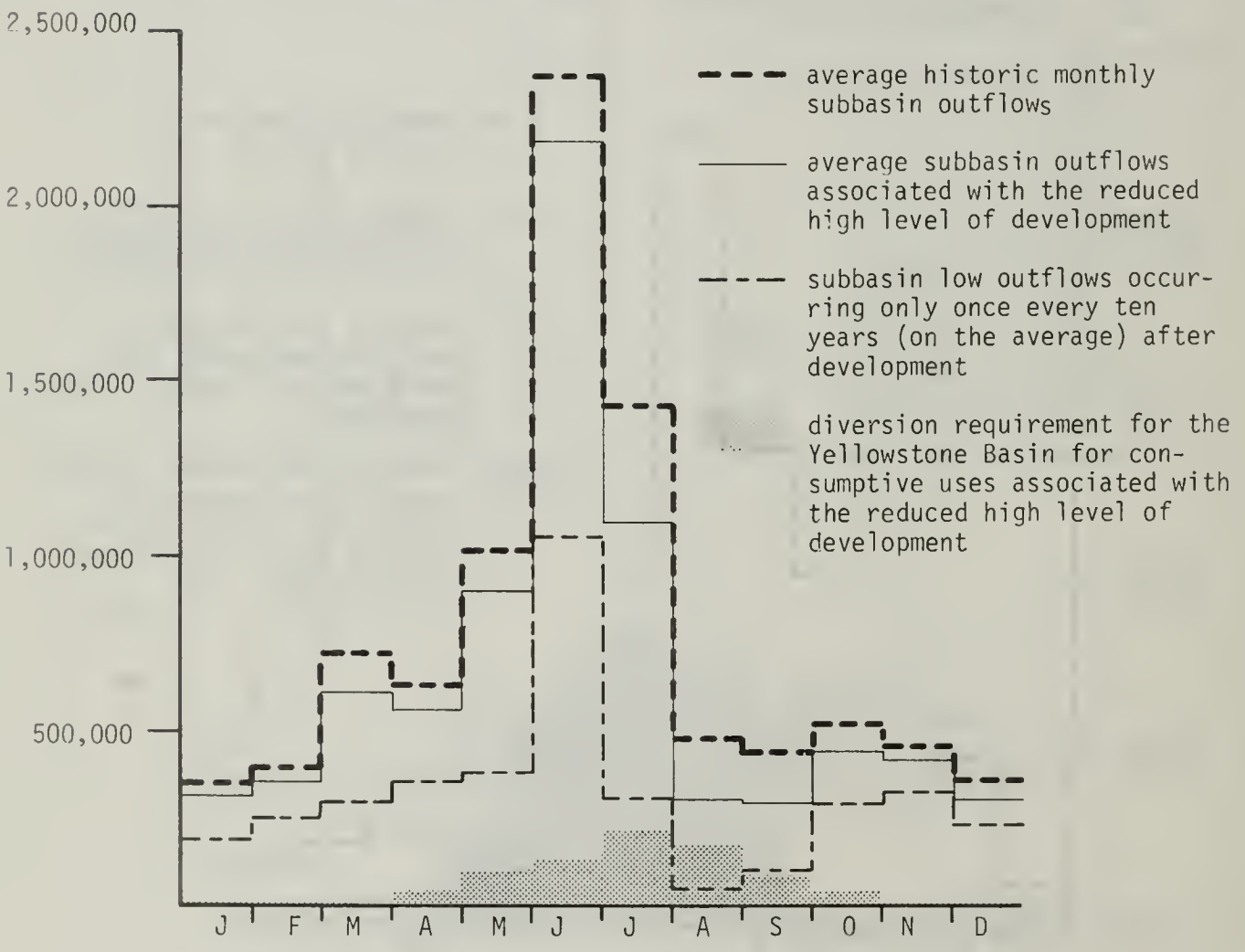
Level of development: 55% of the projected high level of irrigation development and none of the projected energy development
Reservoir active storage: 275,000 af
Subbasin firm annual yield: 124,000 af
Instream flows: no provisions are made for instream flows

Figure 7. Powder River Basin Monthly Outflows at the Reduced High Level of Development.

LOWER YELLOWSTONE

The Yellowstone mainstem is free flowing; the only dams on the river are diversion dams. Even though there is no storage on the mainstem, the water supply is adequate throughout most of the river for most months in most years.

Figure 8 illustrates a possible exception. For the high level of development there would always be an adequate supply of water for diversion and consumption even without mainstem storage, but instream flows would be minimal about one year in ten.



ASSUMPTIONS:

Level of development: all of the projected high level of development, except that, for the Tongue and Powder river subbasins, the high level is reduced as described in Figures 5 and 7.
Instream flows: no provisions are made for instream flows.

Figure 8. Lower Yellowstone Subbasin Monthly Outflows at the Reduced High Level of Development.

PART III

THE IMPACT OF INCREASED DEVELOPMENT ON INSTREAM WATER USE

The Yellowstone River, its tributaries, and associated riparian land, vegetation, and wildlife make up a complex, interacting, ecological system. This system is affected by many variables, some of which are relatively unaffected by man, for example, geology and climate. Other variables can and have been manipulated by man, for example, land use (especially agriculture), water pollution, channel form (through such activities as riprapping), and flow (through such projects as dams and diversions).

Flow is of present interest because of pressures to allocate the waters of the basin to various agricultural and industrial developments and because of widespread concern for the maintenance of instream flows. This section of the report summarizes the limited knowledge about the impact of water diversion and consumption on instream uses of water. The information presented here was produced largely through the Yellowstone Impact Study funded by the Old West Regional Commission.

Two of the most important aspects of the river system are water quality and channel morphology (a stream channel's physical characteristics, such as cross-sectional shape, pattern as seen from an airplane, and longitudinal profile). Both are sensitive to man's activities in the watershed,and both have important influences on other important features of the river system, such as riparian wildlife, migratory waterfowl, fish and other aquatic organisms, and recreation.

CHANNEL MORPHOLOGY

CURRENT SITUATION

Yellowstone Basin streams, as they exist today, are the results of dynamic, ongoing channel formation and adjustment processes--erosion, runoff, streamflow, and sediment transport--as well as the geology of the basin. Changes in any of these processes will change the morphology of the channel, which will,in turn, affect other things: the stream bottom habitat available to aquatic insects and other invertebrates, the fish which feed on those invertebrates, the islands used by geese and other migratory waterfowl, and beavers and other furbearing mammals which occupy the land and utilize vegetation adjacent to the river.

Though it has undergone changes, the Yellowstone mainstem exhibits a braided form much like that viewed by Captain William Clark in 1805. This braided form, characterized by multiple channels and islands, is exemplified most by stretches of the river above Forsyth and below Glendive. It provides the necessary habitat for the diversity and abundance of wildlife along the river, but is susceptible to change. Witness the Bighorn River, once also a highly braided river. Since the construction of Buffalo Bill, Boysen, and

Yellowtail dams, the river has consolidated and eliminated islands, tending toward a single channel and eliminating backwater areas. Between 1939 and 1974, from Yellowtail Dam to the mouth, the area of the riparian bank increased 38 percent, the total river area (including water, islands, and gravel bars) decreased 25 percent, the vegetated island area decreased 23 percent, and the area of gravel bars decreased 70 percent. A similar, but undocumented, change probably took place on the Tongue River, now essentially a single channel, following the construction of Tongue River Dam.

The impact of several decades of water diversions on the morphology of the Yellowstone mainstem has been small, principally because the mainstem is still essentially free-flowing. The natural phenomenon which has the most effect on the river channel is the dominant discharge (that high flow, recurring about every other year, which over long periods transports more sediment than any other flow). This discharge occurs during the June peak; on the average, less than 10 percent of the total June flow is diverted for irrigation. Therefore, neither the dominant discharge nor, consequently, the channel morphology have yet been seriously affected.

The major influence on channel morphology has been riprap, which stabilizes the banks and limits the ability of natural processes to operate.

IMPACTS ON CHANNEL MORPHOLOGY

Future changes in channel morphology resulting from the three levels of development considered in this report may be projected, based on the theories of river dynamics and the history of the river basin.

The Yellowstone mainstem should undergo little change in channel morphology as a result of the depletions considered here. Changes in river stage (elevation of the water surface), width, depth, and velocity would be small. However, for the high level of development, the sediment transport capacity may decrease up to 30%. Whether this loss of capacity would cause siltation of the stream bed would depend on the sediment available for transport. The Bighorn River, once a major sediment producer, no longer contributes as much as it once did because of the sediment trap behind Yellowtail Dam. Also, the high development level calls for the construction of Moorhead Dam, which would decrease the contribution of the sediment-laden Powder River.

With regard to the tributaries, development at the levels projected will cause no changes in the Bighorn and Tongue rivers in addition to those resulting from their existing impoundments. A dam on the Powder River would result in severe degradation (down-cutting) of the channel as the stream attempts to regain the sediment load deposited behind the dam. Because the flow reductions in the Clarks Fork Yellowstone River as a result of the projected development are expected to be minor, changes in channel morphology are likewise expected to be minor. There are, however, proposals for dams on the Clarks Fork Yellowstone in Wyoming, which, if constructed, would cause major changes in channel morphology similar to those which occurred in the Bighorn River.

The major factor influencing changes in channel morphology will probably continue to be riprap.

WATER QUALITY

CURRENT SITUATION

For most uses, water must meet an acceptable standard of quality. For example, irrigation water cannot have excessive concentrations of salts (total dissolved solids) or boron. For municipal use, water should be low in iron, total dissolved solids, bacteria, and temperature, but high in dissolved oxygen. For maintenance of healthy instream habitats for aquatic organisms, water should be high in dissolved oxygen, low in total dissolved solids, and contain adequate, but not excessive, nutrients such as phosphorus and nitrogen.

The water quality analysis reported here centers on total dissolved solids (TDS). Essential to this analysis is the assumption that municipal and industrial water pollution will be effectively prevented by the state through its non-degradation policy, and that the principal effect on water quality would therefore result from dewatering and irrigation returns.

The recommended upper limit for TDS for drinking water is 500 mg/l. For irrigation, TDS concentrations from 500 to 1500 mg/l characterize a water as "high salinity"; it cannot be used on poorly drained soils. When TDS concentrations are in excess of 1500 mg/l, water is characterized as "very high salinity," and can only be used on well-drained soils and then only with salt-tolerant crops such as sugar beets, wheat, and barley (alfalfa and corn are less tolerant to salts). In addition, excess water must be applied to leach the salts from the root zone. Using high and very high salinity water for irrigation may aggravate saline seep problems.

For use of water by some industrial processes, TDS is an important consideration. Where TDS concentrations are high, industries will be forced to reduce them through expensive treatment processes.

The existing water quality situation in the Yellowstone Basin is described in an earlier section.

IMPACT ON WATER QUALITY

In the Yellowstone mainstem near Billings, TDS concentrations have historically averaged less than 200 mg/l, exceeding that value only occasionally. Under the high level of development, TDS values, on the average, would not increase significantly, but would show occasional slight increases.

In the mid-Yellowstone mainstem, at the high level of development, TDS concentrations would sometimes exceed 1000 mg/l during August, up from the 600 mg/l or so occasionally experienced during previous Augusts.

Average TDS concentrations would not increase significantly during most months; during August, however, the average TDS value would increase from less than 500 mg/l to more than 700 mg/l.

In the lower Yellowstone mainstem, the impact of the high level of development would also be significant. Average TDS concentrations would increase during August from less than 500 mg/l to about 700 mg/l. Occasional August values would exceed 1200 mg/l, up from about 550 mg/l.

In the Bighorn River, TDS concentrations now average less than 600 mg/l. Under the high level of development, the increases would be slight.

Tongue River TDS concentrations average less than 500 mg/l year-round, reaching about 70C mg/l in December and January. During several months, occasional values of 800 mg/l have been noted. Under the high level of development average TDS values would usually exceed 1000 mg/l and would some years exceed 1600 mg/l year-round.

Water quality impacts in the Powder River would be even greater. Naturally saline with an annual average TDS concentration of over1100 mg/l, the Powder could show an average of over 1300 mg/l under the high level of development. Occasional September TDS values would increase from about 1800 mg/l to over 3500 mg/l.

It may be reasonably concluded that water quality constraints may determine the level of development finally realized, especially in the Powder River, but also in the Tongue River and to some extent in the other tributaries and the mainstem as well.

FISH AND WILDLIFE

PRESENT RESOURCE

The Yellowstone River has survived as one of the last large free-flowing river systems in America. The lack of impoundments leaves the spring peak flows and fall and winter low flows to establish a unique ecosystem, adapted to seasonal and yearly flow variations, that supports an abundant variety of wildlife. From the clear, cold-water trout fishery in the headwaters and upper reaches to the meandering warm-water fishery in the lower basin, the river and its tributaries display a variety of aquatic communities that have remained relatively undisturbed when compared to those of the impounded Missouri, Platte, or Colorado rivers.

The cold-water salmonid fishery is characterized by the presence of cutthroat, rainbow, and brown trout and mountain whitefish. Roughly between Big Timber and Bighorn the river undergoes a transition to the plains warm-water fishery characterized by the presence of carp, goldeye, burbot, stonecat, sauger, walleye, channel catfish, paddlefish, shovelnose sturgeon, and others.

While the Yellowstone River Basin supports a tremendous variety of wildlife including big game species, upland game birds, waterfowl, furbearing mammals, nongame species, raptors, and even endangered species, the river system itself is directly and critically linked to only a portion of these. Canada geese, bald eagles, great blue herons, white pelicans, and several species of ducks use the river for a variety of purposes, including resting, nesting, and feeding. The furbearers, mink, beaver, and muskrat, are totally dependent on the stream systems.

IMPACT ON FISH AND WILDLIFE

Fish and riparian wildlife are affected by many interacting variables, among them, flow. Unfortunately, quantification of the relationships between flow and fish and wildlife populations is not possible at this time.

Impact on the Fishery

Fish are dependent on flow for several life functions: migration, spawning, rearing, and over-wintering.

Reduced flows will slightly decrease the amount of stream bottom available as habitat for the many bottom-dwelling invertebrates, essential as food for many fish species. Reduced water velocities over riffles will tend to reduce the populations of mayflies and caddisflies favored as food by goldeye, channel catfish, freshwater drum, young sauger, young burbot, and, especially, shovelnose sturgeon. Loss of side channels and backwater areas would affect fish feeders such as sauger and burbot.

In the Yellowstone mainstem, peak spring flows are necessary to trigger and maintain paddlefish spawning. The dependence of other fish species on flow is less well known. Quantification of the necessary migration flows is not possible at this time, and, accordingly, the potential impact on the mainstem fishery is not known.

In the Tongue River, the low development level would not have a major impact on the now productive fishery, but the intermediate development level would result in a high adverse impact. Spawning habitat would be greatly reduced every year; riffles would freeze during most winters; fall flows would approach zero about one out of three years; high flows would be inadequate for paddlefish migration; elevated water temperatures and total dissolved solids would often be a problem. Flow reduction associated with the high projection would dewater the stream to the point that the fishery would be virtually eliminated unless instream flows were guaranteed.

Impacts on the Tongue River Reservoir fishery, however, would be minor.

Impacts on Waterfowl

Effects on migratory waterfowl would result from: 1) changes in channel morphology, water levels, and flows, and 2) changes in land use (more irrigated agriculture).

Stabilization of bars and islands and the subsequent encroachment of vegetation would reduce the populations of nesting Canada geese and loafing waterfowl. Loss of island separation from river banks, or the reduction in width or depth of channels, would increase the accessibility of nesting Canada geese, ducks, and mergansers to predators. It is unlikely, however, as discussed above, that such channel changes will be significant on the mainstem.

In some areas along the Yellowstone mainstem (for example, the Bighorn to Hysham section), geese frequently nest in willow stands which have been thinned by beavers. Any changes which reduce beaver populations would therefore tend to discourage goose nesting.

Open bars and islands are important as loafing areas for migratory waterfowl, as territorial defense sites for breeding ducks and geese, and as secure fishing sites for herons. Loss of these areas by siltation and vegetation invasion would adversely affect these birds.

Many migrant ducks and geese use grain fields for feeding. Any level of development which increases the area of these fields would tend to make the valley more attractive to these migrants. Increases in goose and duck populations would benefit eagles and other predators.

Impact on Furbearers

As with migratory waterfowl, the analysis of the effect of water development on riparian furbearers is subjective. A few generalities hold true, however.

Winter flow reductions can result in freezing of beaver caches and muskrat feed beds; entrances to lodges and bank dens may become exposed or frozen. The results would be increased predation and starvation. Increased winter flows could likewise be detrimental; caches could be washed away.

Low flows in early fall stimulate dam-building activities among beavers. Cutting of willows and young cottonwoods for that purpose would decrease the available food supply, weaken bank resistance to erosion during high runoff periods, and reduce the habitat for other wildlife species such as deer, game birds, song birds, and raptors. It may enhance goose nesting, however, as pointed out above.

Impoundment-induced channel changes such as those witnessed in the Bighorn River would tend to replace willow stands, the primary food source for beavers, with mature stands of cottonwood. Beaver populations would be accordingly reduced.

RECREATION

PRESENT ACTIVITY

For many, the Yellowstone is primarily a recreational river providing a broad variety of recreational opportunities. The high-country, cold-water

trout fishery of Yellowstone National Park and the upper river is nationally known. On the lower river, agate picking is a recreational activity that attracts not only hundreds of Montanans but many out-of-staters as well. In warm weather, boaters make use of the entire river. In the fall, most recreationists are hunters. The warm-water fishery of the middle and lower basin is gaining in popularity. The most important feature of recreation in the middle and lower portions of the basin is that recreation activity at the present time is far less than its potential.

The Fish and Game Commission has established 230 miles of the Yellowstone River (from Gardiner to Pompey's Pillar) as an outstanding stream under its recreational waterway system (see the "Stream-Fishery Classification" map following page 42). That river section, in 1970, was designated by the Secretary of Agriculture and the Secretary of the Interior for consideration for inclusion within the National Wild and Scenic River System. Before this section of the river can be included in the system, a 5(d) study (named after the original section 5(d) of the Wild and Scenic Rivers Act) must be completed. (The 1975 Bureau of Outdoor Recreation study (USDI 1975b) investigating the potential impact of the proposed Billings Water Supply Unit did not meet the qualifications for a 5(d) study.)

IMPACT ON RECREATION

Recreation activity, recreation potential, and possible impacts on recreation due to water developments vary along the mainstem. Neither the low nor the intermediate level of development would measurably affect recreational activities. Access to the river, now limited by spring and early summer flooding of unimproved roads, would be improved slightly under both the intermediate and high development levels. Certain recreational activities, particularly boating, floating, and waterskiing, would be adversely affected under the high level of development.

Unknown are how each projected level of development would affect fishing success and, if fishing success were decreased, how that decrease would affect the intensity of fishing. Also unknown is how each level of development would affect the supply of agates for rockhounds.

With regard to basinwide recreation, both fishing and hunting pressures could be expected to increase with increased populations. Attendance at popular camping and other recreation sites could become concentrated.

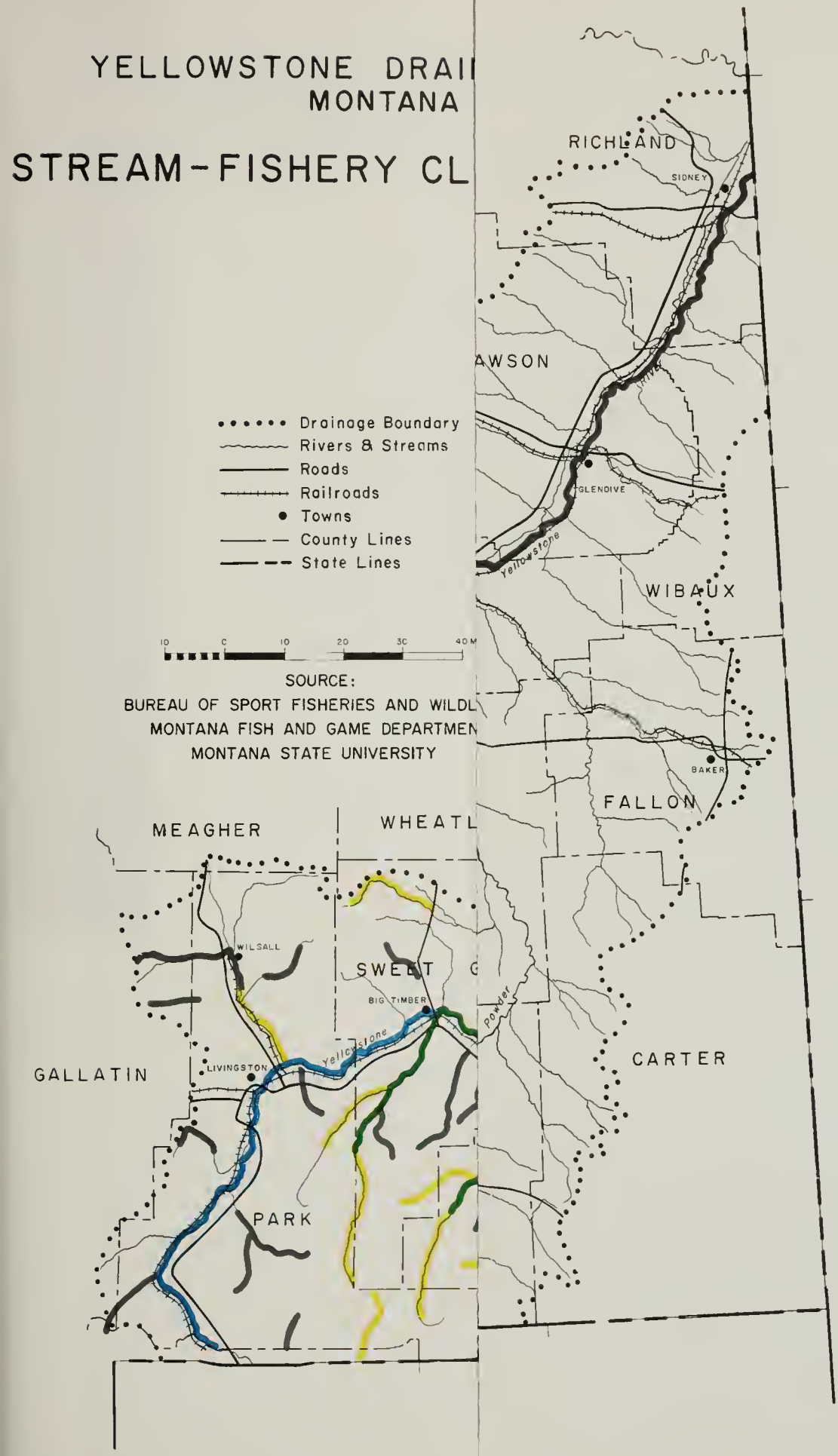
Some land could become unavailable for recreational use, through the siting of development facilities, and through an elsewhere-observed tendency of landowners to close private lands as population and recreational use increase.

The expected reduction in the quality of the Tongue and Powder rivers' waters may affect swimming, picnicking, and other recreational use.

CLASS	SIGNIFICANCE	RIVER & REACH	MILES
1	NATIONAL	YELLOWSTONE RIVER, Yellowstone Park boundary to mouth of Boulder River	103
2	STATEWIDE	BOULDER RIVER, natural bridge to mouth	34
		YELLOWSTONE RIVER, mouth of Boulder River to rapids	50
		STILLWATER RIVER, below U.S. Forest Service Woodbine Camp	45
3	REGIONAL	YELLOWSTONE RIVER, rapids to Laurel	20
		BIGHORN RIVER, 20 miles below afterbay	20
		LODGE GRASS CREEK	46
		LITTLE BIGHORN RIVER, above Lodge Grass	51
		EAST ROSEBUD CREEK	36
		WEST ROSEBUD CREEK	30
		WEST FORK STILLWATER RIVER	12
		STILLWATER RIVER, above U.S. Forest Service Woodbine Camp	20
		SLOUGH CREEK	10
		BOULDER RIVER, Upsidedown Creek to natural bridge	24
		WEST FORK BOULDER RIVER, above McLeod	20
		SHIELDS RIVER, below Cottonwood Creek	22
		SWEETGRASS CREEK, above Melville	20
4	LOCAL		

YELLOWSTONE DRAI
MONTANA

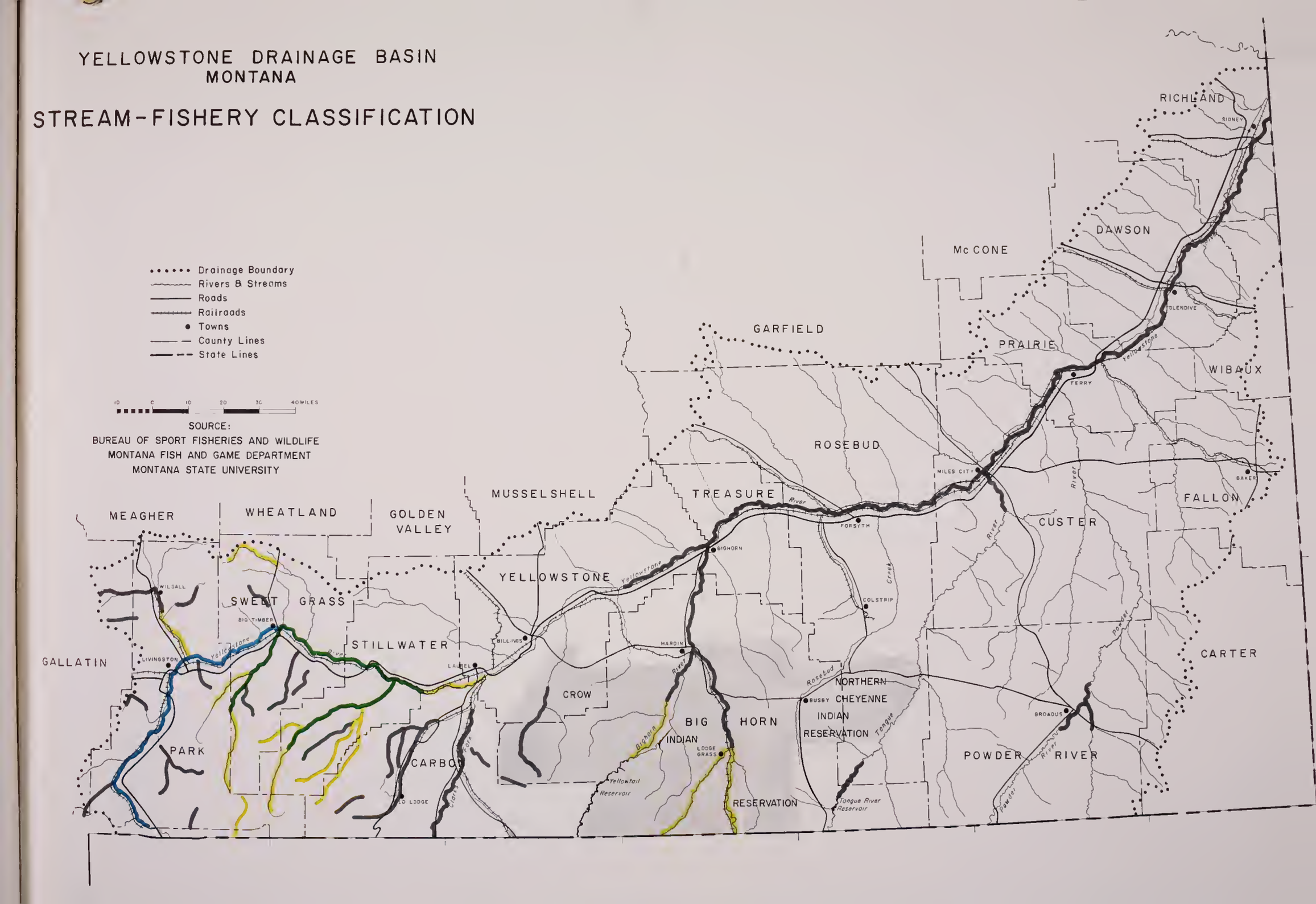
STREAM-FISHERY CL



SOURCE:
BUREAU OF SPORT FISHERIES AND WILDL
MONTANA FISH AND GAME DEPARTMEN
MONTANA STATE UNIVERSITY

YELLOWSTONE DRAINAGE BASIN
MONTANA

STREAM-FISHERY CLASSIFICATION



The recreational experience of hikers could be diminished in some areas, since such development facilities as transmission lines intrude upon the natural aesthetic quality. Sightseers who value naturalness and solitude could be similarly affected; those who are more gregarious or who find the opportunity to tour development facilities interesting and educational could be benefited.

The recreational experience of hikers could be diminished in some areas, since such development facilities as transmission lines intrude upon the natural aesthetic quality. Sightseers who value naturalness and solitude could be similarly affected; those who are more gregarious or who find the opportunity to tour development facilities interesting and educational could be benefited.

PART IV

WATER RIGHTS

The actual amount of water available in the Yellowstone Basin for industrial or agricultural development or the provision of instream flows cannot now be positively quantified. Questions in the following five areas must first be resolved: existing water rights, Indian water rights, federal water rights, existing water rights litigation, and the Yellowstone River Compact.

EXISTING WATER RIGHTS

The Montana Water Use Act of 1973 provides a permit system for the appropriation and new use of surface and ground water, procedures for the determination and court adjudication of water rights existing prior to July 1, 1973, and the establishment of a centralized record system of all water rights.

Because of Montana's lack of documentation concerning valid water use, water supply problems and implications of industrial applications, it was decided that the initial determination of existing water rights would be in the Yellowstone River Basin. Field investigations of water right declarations, part of the process of preparing a recommendation to the district court which issues the preliminary and final decree for adjudication, have been underway since the summer of 1974 in the Powder River Basir; the current status of the process is shown in figure 9. So far, field investigations have been completed on Ash Creek, Hay Creek, and the East Fork of the Little Powder River and are underway on the Little Powder River. It is estimated that there will be a total of about 9,000 water rights recommended to the district court in the basin. Of the 1,000 rights investigated so far, about 50% are use rights--rights which have never been filed.

The statutory adjudication of the other three interstate tributaries (Tongue, Bighorn, and Clarks Fork Yellowstone) will be completed next. In fact, preparations for the determination of existing rights have begun in the Tongue and Bighorn river basins, but orders for declarations are currently pending because of litigation in federal court over Indian and federal water rights. Adjudication of the mainstem of the Yellowstone River will follow.

Until the adjudication process is completed, quantification of water rights is not possible. Under Montana law prior to July 1, 1973, an appropriator could divert water for a number of years without filing, submit a declaration for a water right, and possibly receive a valid right. Consequently, water rights usually are not adequately reflected in historical flow records.

INDIAN WATER RIGHTS

Present recognition of Indian "reserved" water rights began with the United States Supreme Court's decision in the Winters case in 1908.

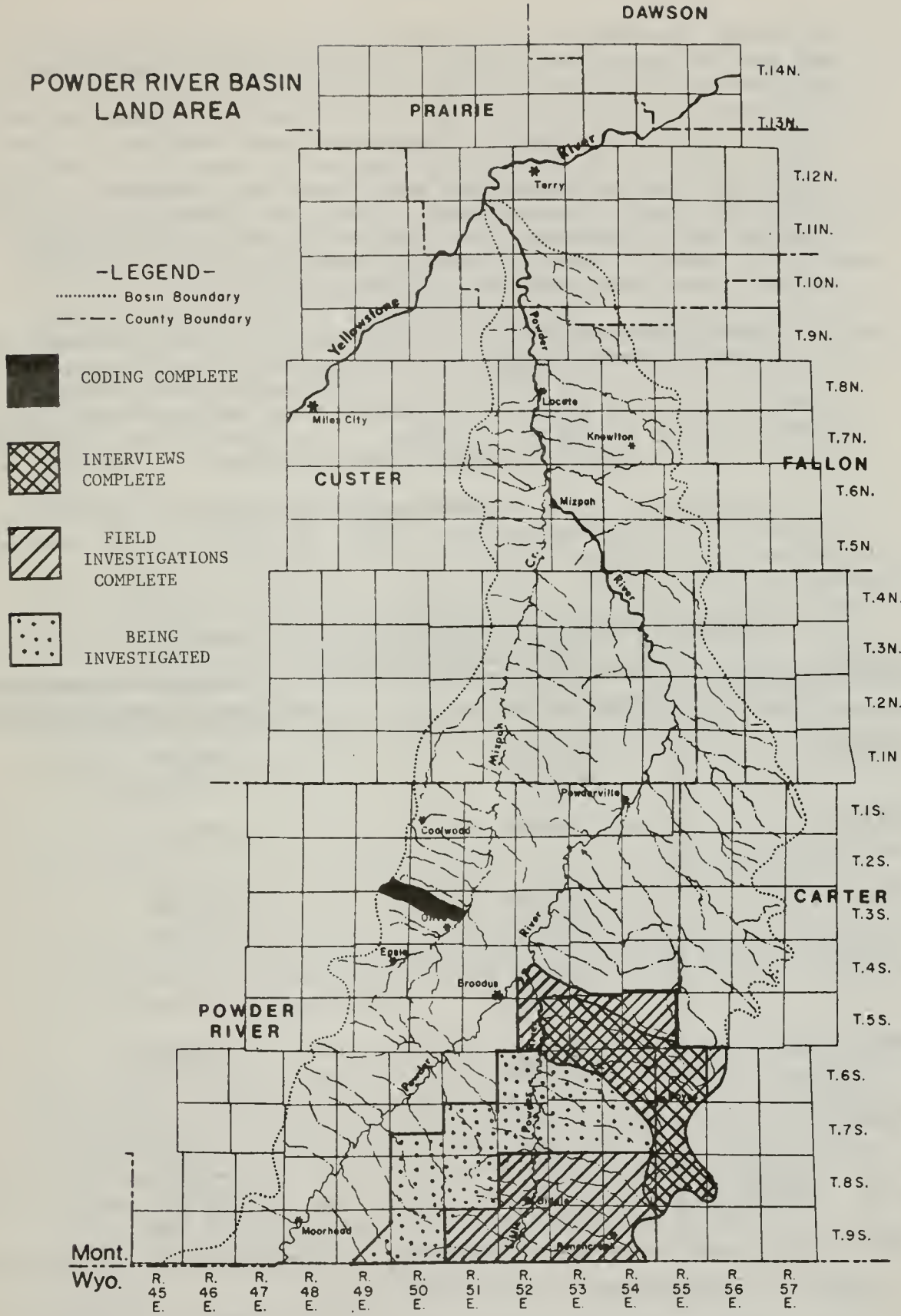


Figure 9. The status of the Water Rights Adjudication Process in the Powder River Basin.

The Winters Doctrine, as it has been developed over the years, holds that when the Indian tribes ceded their lands to the United States, reserving smaller tracts for their own use, sufficient water to fulfill their needs on the reservation was also reserved. The measure of the reserved right is in dispute, although some courts have measured the right according to the irrigable acreage on the reservation. The reserved right does not depend upon actual use, and is therefore available for future as well as present needs. Thus, even if the quantity of the reserved right is determined, the question arises as to whether that water can be put to uses (such as coal-based industrialization) which were not contemplated when the reservation was created.

Since major tributaries of the Yellowstone flow by or through both the Crow and Northern Cheyenne reservations, the Indians' reserved rights will affect other water uses. It is possible that Indian reserved rights can be quantified in Montana state courts with the United States acting as trustee of the tribes. If so, much of the uncertainty which currently surrounds Indian reserved rights would be removed.

An estimate by the U.S. Department of the Interior of water requirements on the Yellowstone Basin Indian reservations by the year 2020 is shown in table 15.

TABLE 15
ESTIMATED INDIAN WATER REQUIREMENTS BY THE YEAR 2020
(ACRE-FEET PER YEAR)

	Crow Reservation	Northern Cheyenne Reservation
Agriculture	1,080,000* (540,000)	109,200 (54,600)
Wildlife	828,300 (0)	178,800 (0)
Energy	196,500 (196,500)	196,500 (196,500)
Industrial	7,000 (1,540)	300 (60)
Domestic	1,800 (400)	1,400 (300)
Recreation	500 (110)	300 (60)
TOTALS	2,114,100 (738,550)	486,500 (251,520)

SOURCE: U.S. Department of the Interior 1975.

* First number represents water diverted or used instream; the figure in parentheses indicates the amount of water consumed.

FEDERAL WATER RIGHTS

Reserved rights attach, not only to Indian lands, but to any lands the United States has withdrawn from the public domain for federal purposes. Upon withdrawing the lands, the United States impliedly withdrew or reserved sufficient water to satisfy the federal purposes. Included in this category are most National Forest lands, national parks, recreation areas, and wildlife refuges. The same problems of quantification seen with Indian rights apply to these federal reserved rights. It is clear, however, that federal reserved rights can be quantified in State courts.

EXISTING WATER RIGHTS LITIGATION

FEDERAL AND INDIAN WATER RIGHTS LAWSUITS

The most important pending litigation concerning water rights in the Yellowstone River Basin concerns three lawsuits currently pending in Federal District Court in Billings. Two of the actions were brought by the United States in its own behalf and on behalf of the Crow and Northern Cheyenne tribes to have adjudicated the water rights in the Tongue and Bighorn river drainages. The third suit was brought by the Northern Cheyenne Tribe in its own behalf to have adjudicated its reserved water rights in the Tongue River and Rosebud Creek. There are several thousand private water users and several state agencies named as defendants in the three lawsuits.

These actions have not yet gone to trial, and it is unlikely that they will be tried in the near future. There are currently motions to dismiss before the court, filed by the state and most of the private users. These motions argue generally that the proper forum for adjudication of all of these water rights, federal, Indian and private, is in Montana district courts pursuant to the Montana Water Use Act. Until this basic jurisdictional question is finally resolved, there will be no further action in these cases.

The importance of these actions is substantial, since, whether they are tried in state or federal court, they could answer the question of the extent of federal and Indian reserved water rights in the Yellowstone River Basin. The adjudicating court will have to determine the reserved water rights, and it may also determine such important questions as whether the Indian right is ultimately quantifiable, or, as the Indians have claimed, open-ended, and whether the reserved waters can be used or sold for use outside the boundaries of the reservations. In view of the complexity of the pending procedural issues, however, these questions will not soon be answered.

INTAKE WATER COMPANY LAWSUITS

Another important series of lawsuits concerning water rights in the

Yellowstone River Basin involves Intake Water Company, Inc., a wholly-owned subsidiary of Tenneco, Inc., of Houston, Texas. The basis of the three separate actions to which Intake is a party is its claim to an existing right to appropriate 111.4 cfs from the Yellowstone River near Intake, Montana. Intake has successfully defended its claim in Montana District Court to a perfected appropriation for sale, rental, and distribution for irrigation, industrial, municipal, and domestic purposes. General plans have been revealed to sell water to "companies with energy generating or conversion plants within or outside the State of Montana, including its parent corporation, Tenneco, Inc. The judgment of the District Court upholding Intake's claimed appropriation is currently under appeal to the Montana Supreme Court.

A separate action instituted by Intake against the Yellowstone River Compact Commission in Federal District Court seeks a declaratory ruling that Article X of the Yellowstone River Compact is unconstitutional in that it requires unanimous consent of the three signatory states before any water can be diverted from the Yellowstone River Basin. This case is currently stayed, pending a resolution of the issues in the lawsuit mentioned in the preceding paragraph, and none of the issues raised has yet been resolved.

In a third separate action, Intake has sued the DNRC in Montana District Court seeking a declaratory ruling that its planned diversion of 111.4 cfs from the Yellowstone River, for the purposes described above, is not subject to the Montana Major Facility Siting Act (Section 70-801, et seq., R.C.M. 1947). This case is also currently pending.

The outcome of all three of these actions is important because there are several corporations with similar large claims for Yellowstone Basin water for industrial purposes. Furthermore, the action in Federal District Court is the first to interpret and challenge the Yellowstone River Compact. Thus, final resolution of these actions could likely determine the validity of other claimed rights from the Yellowstone, and could significantly affect the future viability of the Yellowstone River Compact.

Another series of lawsuits to which Intake Water Company is a party involves competing water development projects on the Powder River between Intake and Utah International, Inc. The issues raised are very complex, but generally involve the question of whether Intake or Utah International has the prior claim to water from the Powder River. The two lawsuits--one in State District Court and the other in Federal District Court--require interpretation of the Yellowstone River Compact and the water appropriation laws of the states of Montana and Wyoming. Both actions are currently pending, awaiting resolution of preliminary jurisdictional and procedural issues.

YELLOWSTONE RIVER COMPACT

The Yellowstone River Compact, executed by Montana, Wyoming, and North Dakota, and ratified by the United States Congress in 1950, was designed to allocate water of the Clarks Fork Yellowstone, Bighorn,

Tongue, and Powder rivers. The compact recognizes water rights prior to 1950, those rights designated to provide supplemental water supplies to land irrigated prior to 1950, and water rights for irrigation projects started before 1950. The compact divides the remaining water according to percentages of the flow at the mouths of the streams as shown in table 16.

TABLE 16

DIVISION OF WATERS UNDER THE YELLOWSTONE RIVER COMPACT

Tributary	Wyoming	Montana
Clarks Fork Yellowstone	60%	40%
Bighorn	80%	20%
Tongue	40%	60%
Powder	42%	58%

Article X of the compact prohibits diversion of water out of the Yellowstone Basin without the unanimous consent of the signatory states. This article has recently become controversial because Wyoming would like to divert water out of the basin for energy conversion. Montana's position at this time is to withhold approval of such diversions until the two states can agree on quantification of the percentages of tributary flows. Wyoming has published its estimates of these quantities, as presented in table 17. Montana does not necessarily agree and intends to independently calculate its compact share.

TABLE 17

WYOMING'S YELLOWSTONE COMPACT ESTIMATES (ACRE FEET)

	Wyoming	Montana
Clarks Fork Yellowstone	429,000	285,000
Bighorn	1,800,000	400,000
Tongue	96,400	144,700
Powder	120,700	166,600
TOTAL	2,446,100	996,300

SOURCE: Wyoming State Engineer's Office 1973

PART V

RESOLVING THE CONFLICTS: THE STATE WATER PLAN

POTENTIAL SOLUTIONS TO SOME WATER CONFLICTS IN THE YELLOWSTONE BASIN

The conflicting demands for Yellowstone water, both present and potential, have been presented in the preceding parts of this report. Reconciliation of these conflicts requires thorough consideration of each potential solution described below.

WATER RESERVATIONS

A major provision of the Water Use Act is that Montana or any of its political subdivisions or agencies, or the United States or any of its agencies (except in the Yellowstone River Basin), may apply to the Board of Natural Resources and Conservation to reserve water. These reservations may be made for existing or future beneficial uses or to maintain a minimum flow, level, or quality of water. A reservation has the same legal standing as a permit. Those water rights with earlier priority dates must be honored first until their needs for beneficial uses are met.

The Yellowstone Moratorium, enacted in 1974, affected major applications for appropriations of greater than 20 cubic feet per second (cfs) or a planned storage of greater than 14,000 acre-feet in the Yellowstone River Basin. The DNRC may not take any action on these applications until March 1977. The moratorium also provides that water reservation requests adopted by the Board before these major applications for permits are acted upon will have a preferred use over those applications, if granted. Major applications for permits for beneficial use thus affected are shown in appendix B.

Reservation applications received to date are also listed in appendix B. The largest has come from the Montana Fish and Game Commission, which requested a reservation of 7.1 mmaf/y for instream flow in the Yellowstone mainstem at Sidney. Additional requests will be submitted concerning major tributaries. Thirteen conservation districts and one municipality in the basin have filed letters of intent to apply for reservations.

The Board has not yet acted on Yellowstone reservation applications and will not until the DNRC completes an environmental impact statement on those applications. The final impact statement will be available in February 1977.

IRRIGATION WATER MANAGEMENT

By reducing irrigation water waste, more water could be made available for further diversion or instream use.

Main canals are sometimes kept full throughout the irrigation season, even though actual water need may be small. In these cases, more water is diverted than is needed, with much water being lost from the irrigation system at wasteways.

Water costs are generally low compared to farm labor costs, sometimes resulting in wasteful water application practices. Over-application of irrigation water not only wastes water but also leaches fertilizer, resulting in financial losses and degraded water quality downstream. (However, excess water application may be needed in some cases to leach salts which have accumulated in the root zone.)

Sound management techniques can correct these problems and result in less water being diverted to irrigate the same number of acres.

Contributing to irrigation problems is the deterioration with age of the water distribution networks in the basin. These systems also aggravate water losses, but can be upgraded by such means as canal and ditch lining, proper wasteway construction, and provisions for adequate cross drainage structures.

In many areas water users have legal rights to water lost by irrigators above them, and their rights could be adversely affected by the use of more efficient irrigation practices. Even though irrigation management may provide more water for other uses, thorough and comprehensive studies must first be completed to ensure that all water rights are protected.

INCREASED STORAGE

The primary purpose of a reservoir is to retain water in periods of high flow for use during times of drought or shortage. Total reservoir capacity refers to the maximum amount of water the reservoir can hold; however, some of this storage cannot be used for downstream diversion requirements because the reservoir must be maintained at minimum levels for recreation and hydropower purposes and because reservoir storage must be provided for flood flows when they occur. The storage available for consumptive use, therefore, is normally less than the total capacity.

Firm yield is the most important aspect to consider when matching water availability with demand, since it is the maximum quantity of water that can be guaranteed annually from the reservoir even during dry years. Firm yield is affected by physical factors, such as reservoir characteristics and monthly and yearly fluctuations of streamflow, and institutional factors, such as existing water rights, interstate compacts, and minimum instream flow provisions.

New reservoirs could alleviate some of the basin's water supply problems, but not all. The Allenspur dam site alone could furnish 1.5 mmaf of water annually and still provide a measure of fishery protection through releases for instream flows. However, the reservoir would inundate 35 miles of "Blue Ribbon" trout stream and 32,000 acres of agricultural land, much of which is irrigated hay land. Lissa, another mainstem reservoir site, would provide

more water and perhaps be less degrading environmentally. A series of three offstream sites, Sunday Creek, Cedar Ridge, and Buffalo Creek, could provide a major portion of the water that would be firmed up by Allenspur and, according to a Fish and Game Department evaluation, be less damaging to the fish resource. Storage must be built before any significant new water development can take place in the Tongue and Powder river basins.

Table 18 shows the storage potential of selected reservoirs; a more complete listing is given in the "Potential Reservoir Sites and Major Industrial Water Applications" map following page 18 .

TABLE 18

STORAGE AND COST COMPARISON OF SELECTED POTENTIAL YELLOWSTONE BASIN RESERVOIRS

SELECTED RESERVOIR SITE	TOTAL CAPACITY (af)	FIRM YIELD (af/y)	SURFACE ACRES	COST (1976 Dollars)	WATER CHARGE $/af/y+
Allenspur	4,000,000	1,483,000*	31,900	380,282,000	
Lissa	2,180,000	1,944,000*	40,000	170,248,000	
Sunday Creek**	678,000	957,000*	13,700	167,040,000	
Cedar Ridge	127,000	70,000*	4,700	35,788,000	31.10
Buffalo Creek	73,000	40,000*	1,900	54,104,000	81.05
New Tongue Stage I	320,000	100,000***	7,600	63,194,000	39.10
Stage II	450,000	112,000***	9,000		
Moorhead	1,150,000	129,000*	18,500	93,776,000	41.40

*NGPRP 1974. Figures are based on the following assumptions:

1. All water requirements are for industrial use.

2. Fish and Wildlife Service recommended instream flows are maintained except for Moorhead, where, for the Powder River, only 10% of the recommended flows are honored.

**The firm yield of the Sunday Creek offstream storage site is larger than the total capacity of the reservoir because the firm yield includes the amount of water available from the mainstem Yellowstone.

***Bechtel 1969

+No water charge figures are available for the Allenspur, Lissa, or Sunday Creek sites because no information is available regarding the quantity of water that would be marketed from those reservoirs. Interest during construction was computed using 6% interest and a probable construction period. Investment was amortized for 50 years at 5 3/4%. Costs for Stage II of the New Tongue site have never been estimated.

The firm yields shown in table 18 for the Allenspur, Lissa, Sunday Creek, Cedar Ridge, and Buffalo Creek sites were taken from the NGPRP's Report of the Work Group on Water (1974) and indicate water available after allowing for a fairly high level of instream flows (4.3 mmaf/y at Sidney). The firm yield of Moorhead shown also comes from that report but assumes only a low level of instream flows. Firm yields shown for the New Tongue sites are results of a 1969 Bechtel study prepared for the DNRC and include effects of the Yellowstone Compact, but do not allow for instream flows.

ALTERNATIVE ENERGY TRANSPORTATION SYSTEMS AND CONVERSION TECHNOLOGY

Transporting Coal

The principal means of transporting coal is by railroad unit cars.

Slurry pipelines are a method by which a coal and water mixture can be shipped from the mine to the area of conversion. The Yellowstone Impact Study projections show no slurry export from the state at the low level of development, but slurry is included in the intermediate and high levels. It should be noted that under present law the use of water for slurry to export coal from Montana is not a beneficial use.

A 1,000-megawatt electric generation plant requires about 4 million tons of coal per year; conversion of that coal would require about 15,000 acre-feet of water each year. Since 750 acre-feet of water is needed to move one million tons by coal slurry pipelines, exporting the same amount of coal by slurry would require only 3,000 acre-feet of water annually. Only negligible amounts of water would be consumed in exporting the same amount of coal by rail.

Obtaining Water

Many coal beds are miles away from surface water sources adequate to supply coal conversion facilities. Thus, for coal conversion, coal must be shipped to the water source, surface water must be delivered to the coal sites, or ground water must be developed.

Aqueducts. One means of transporting water to Montana's coal fields for use in the conversion process is by aqueduct. The Bureau of Reclamation's Appraisal Report on Montana-Wyoming Aqueducts (USDI 1972a) identified feasible aqueduct routes throughout the Yellowstone Basin. The Northern Great Plains Resource Program has estimated the cost of water delivered through aqueducts to vary from about $25 to $370 per acre-foot, depending on the distance the water is conveyed (NGPRP 1974).

Ground Water. Ground-water aquifers near the surface do not generally yield sufficient water for large-scale development except in the alluvium; however, deep aquifers may be able to provide an amount of water sufficient for industrial use. The Madison Group constitutes the top part of these aquifers. Large-yield water wells can be developed in areas of significant

Madison Group thickness. The Madison and underlying carbonates contain water of moderate-to-good quality that is probably suitable for industrial use, although marginal-to-unsatisfactory for irrigation. Estimates made in the NGPRP study indicated the cost of Madison ground water would vary between $27 and $48 per acre-foot (NGPRP 1974).

Depths to water, yields, and water quality vary widely for the Madison Group, and more specific studies must be completed before industries will be willing to drill for that water. The U.S. Geological Survey is presently coordinating a study that will more closely define characteristics of the Madison ground water.

Dry Cooling

Water, essential in all energy development facilities, is used primarily for cooling in the coal conversion process. As shown in table 19, wet cooling systems consume large amounts of water, while dry cooling techniques are the most water-conservative of the alternatives.

While dry cooling facilities use less water than other cooling methods, they are also the most expensive. However, recent studies have indicated that, if the cost of water reaches approximately $200 per acre-foot (Stroup and Townsend 1974), dry cooling techniques become economically feasible. Though far from common, generation plants using dry cooling do exist. The Neal Simpson Station (27 mw) outside of Gillette, Wyoming, was the first coal-fired electrical generation plant in the United States to use dry cooling. The Wyodak plant, now under construction at the same site and scheduled for completion early in 1977, will also use dry cooling; it will generate 330 mw of electricity and consume from .2 to 1 mgd (Black Hills Power and Light Company and Pacific Power and Light Company 1973). In comparison with the 5 mgd consumed by each of Colstrip Units 1 and 2 (table 5), the Wyodak plant is obviously more water-conservative.

TABLE 19

WATER REQUIREMENTS FOR COAL-FIRED ELECTRIC GENERATING PLANTS

Cooling System	Depletion (af/y/1,000-mw unit)
Evaporative Cooling	15,000
Pond	10,000
Once Through	3,600
Dry Cooling	2,000

SOURCE: Western States Water Council 1974

ADJUDICATION

Resolving the conflicts over water use in the Yellowstone Basin requires that the present water rights be known. As explained earlier in this report, adjudication of existing rights is proceeding, but slowly. Acceleration of that process would be helpful, but that acceleration would, of course, require more professional staff and an increased budget for field offices in those areas.

STATE WATER PLANNING PROGRAMS

Development of a comprehensive, coordinated multiple use water plan for the state was authorized under the Montana Water Resource Act of 1967. That plan, to be known as the State Water Plan, will constitute state water policy; it will set the guidelines for the selection of a course of development of Yellowstone Basin water, and, indirectly, the type of Yellowstone Basin coal development. The water availability discussions in this report show that there is not sufficient water for maximum irrigation development and maximum energy development in all areas of the basin. The State Water Plan may provide a method of determining how much irrigation and how much coal development can or will be accommodated, and to what extent development will be allowed to affect such instream uses as recreation and maintenance of fish and wildlife habitat.

The DNRC's efforts toward fulfilling the mandate of the Water Resource Act have consisted of the publication of a series of reports detailing the state's water resources and participation in a number of studies which have provided and will provide the basis for formulation of the plan. Beyond that, there are temporary but serious obstacles to the finalization of the State Water Plan. One is the unsettled legal status of water rights in the basin. Another is that, although the act calls for coordination of all federal, state, and local activities in the planning and utilization of the state's water resources, it provides no mechanism for implementation of that coordination. Consequently, the water planning program has had to rely on every available resource to achieve some semblance of coordination from the different levels of government. Montana's membership in two river basin commissions, federal-state entities established by the President, has provided a measure of federal and interstate coordination.

One of the studies in which Montana is participating that provides direct input into the State Water Plan is a level B (reconnaissance) study of the Yellowstone Basin and adjacent coal areas, for which federal funding was made available through the Missouri River Basin Commission. Montana had requested this study, hoping for a start in the fall of 1974. The study management was established in July 1975, and the study got underway in January 1976. Because the formulation of the State Water Plan is heavily dependent on the results of this study, that delay resulted in a corresponding change in the projected schedule of the Yellowstone portion of the State Water Plan. Originally scheduled for completion early in 1977, that date has now been delayed until mid-1978 (see figure 10) to allow incorporation of the Yellowstone Level B results.

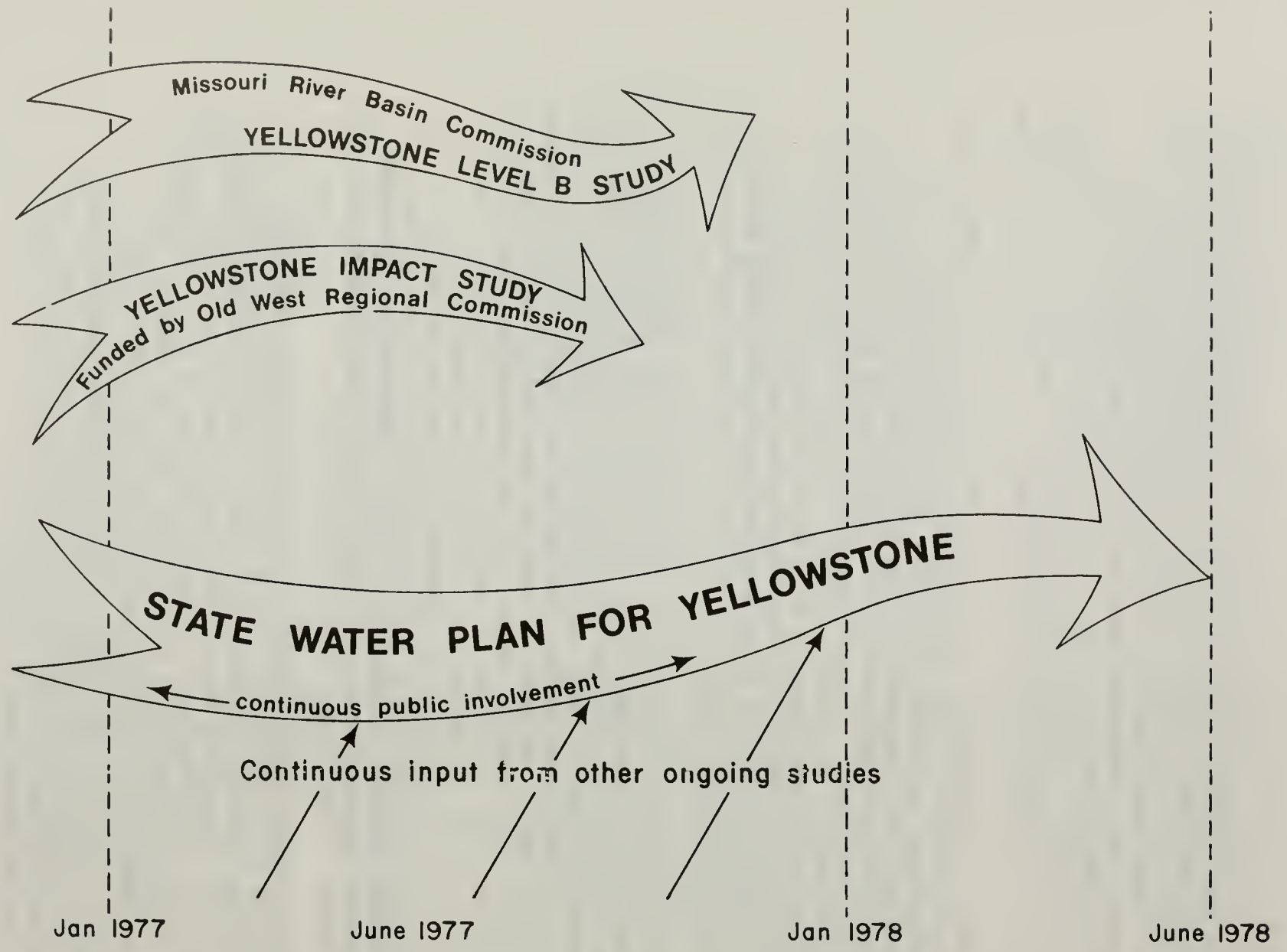


Figure 10. Preliminary Schedule for the Completion of the State Water Plan and Associated Studies.

The federal funding for the Level B provides only for study management and participation from the concerned federal agencies. In order to provide state input, a state planning team was formed to include representatives from various state agencies, thereby drawing upon available expertise.

One shortcoming of the Level B Study is that it must rely on existing, available data with no provision for collecting new information. Montana is fortunate to have a number of ongoing or recently completed studies that are providing valuable information to the Yellowstone Level B Study. A significant contribution is coming from the Yellowstone Impact Study funded by the Old West Regional Commission. Started in mid-1974, this study is providing an analysis of the physical and biological impacts of water withdrawals on the middle and lower reaches of the Yellowstone River and its major tributaries. With funding provided by the U.S. Bureau of Reclamation, DNRC updated for this study the inventory of irrigated lands in the Yellowstone Basin. Much of the previous data was at least 30 years old, so this effort was essential to determining the present status of irrigated agriculture in the basin.

Special studies on the Tongue and Powder rivers were provided for by the 1975 Legislature as part of the Renewable Resources Development Act (HB 642). These studies are examining alternatives for developing additional storage on the Tongue River and the desirability and feasibility of providing storage on the Powder River, presumably at the Moorhead site.

SUMMARY

This report presents an overview of the existing and possible future demands on the water resources of the Yellowstone River Basin and, when adjusted to reflect the public input gained at the hearings to review this draft, should assist the state legislature in making decisions related to the allocation of the waters of the basin. The Yellowstone River carries an average of 8.8 million acre-feet of water out of the state each year; much of that is available for use, but just how much, and where, and at what times of the year, are not confidently known, primarily because most water rights in the basin have not been quantified. Two of the tributaries, the Tongue and the Powder, are not, under current conditions, dependable sources for appropriation for additional continuous, year-round use or even for the full irrigation season.

In order to illustrate how much future development could reasonably be expected to take place in the basin, projections of future irrigation, municipal, and industrial development and water consumption are presented in this report. They were developed for a current Department of Natural Resources and Conservation study of the physical, biological, and economic effects of water withdrawals from the Yellowstone River. These projections for the year 2000 are summarized in tables 20 and 21; they are presented by subbasin elsewhere in this report.

Even though the overall water resource of the basin is adequate in quantity (average 8.8 mmaf/y at Sidney) to satisfy the maximum increase (0.8 mmaf/y) shown in table 20, water availability is a problem. It will not be possible to meet all requirements at the times and places projected, due to seasonal variations in flow and local scarcity of

TABLE 20

INCREASED WATER REQUIREMENTS FOR CONSUMPTIVE USE
IN THE YELLOWSTONE BASIN
IN 2000

Level of Development	Irrigation		Municipal		Energy*	Total Increase** in Depletion (af/y)
	Acreage Increase	Increase in Depletion (af/y)	Population Increase	Increase in Depletion (af/y)	Increase in Depletion (af/y)	
Low	79,170	158,340	56,858	5,880	48,350	212,570
Intermediate	158,310	316,620	62,940	6,960	147,160	470,740
High	237,480	474,960	94,150	10,620	326,740	812,320

* Details of the water requirements for energy use are shown in table 20.

** This total assumes that the same level of development occurs in all use categories.

water in some of the subbasins. In some areas, consumptive requirements would be satisfied only by sacrificing instream uses, providing additional storage, or establishing interbasin transfers of water with aqueducts.

The dewatering that would result from increased consumption would affect the river system. There would be some effect, for instance, on

TABLE 21

INCREASED WATER REQUIREMENTS FOR COAL DEVELOPMENT IN THE YELLOWSTONE BASIN IN 2000

Level of Development	Coal Development Activity						
	Electric Generation	Gasification	Syncrude	Fertilizer	Export	Strip Mining	Total
COAL MINED (mmt/y)							
Low	8.0	7.6	0.0	0.0	171.1		186.7
Intermediate	24.0	7.6	0.0	0.0	293.2		324.8
High	32.0	22.8	36.0	3.5	368.5		462.8
CONVERSION PRODUCTION							
Low	2000 mw	250 mmcfd	0 b/d	0 t/d			
Intermediate	6000 mw	250 mmcfd	0 b/d	0 t/d			
High	8000 mw	750 mmcfd	200,000 b/d	2300 t/d			
WATER CONSUMPTION (af/y)							
Low	30,000	9,000	0	0	*	9,350	48,350
Intermediate	90,000	9,000	0	0	31,910	16,250	147,160
High	120,000	27,000	58,000	13,000	80,210	22,980	321,190

* No water consumption is shown for export under the low level of development because, for that development level, it is assumed that all export is by rail, rather than by slurry pipeline.

the primary recreational activities in the basin. No perceptible impact would result from the activities associated with the low level of development. The high development level, however, would dewater the river to the point that boating, waterskiing, and other activities would be negatively affected. Fish and riparian wildlife would likewise be adversely affected by dewatering projected in the high level of development, especially in the tributaries.

Contributing to the difficulty of determining how much water is still available for use in the basin is the lack of quantification of existing water rights. The adjudication of existing rights in the Powder River Basin, now underway, is a time-consuming process. There are about 9,000 water rights, each of which must be investigated in the field. The status of Indian water rights is unclear. There can be no question of their existence, but their size is in dispute. Similarly, federal reserved water rights in the Yellowstone Basin have never been quantified. Current litigation, especially three lawsuits brought by or on behalf of the Crow and Northern Cheyenne tribes may help resolve some of these issues concerning water rights.

There are other questions concerning the Yellowstone River Compact. This document allocates to each of the two states a percentage of adjusted flows of the Yellowstone tributaries that flow out of Wyoming into Montana. However, it does not clearly define the assumptions needed to adjust flows before those percentages can be converted to actual volumes of water. As a result, the two states have not yet agreed on how to administer the compact.

There are potential solutions to some of these water conflicts. The reservation of water for future beneficial use, including instream flow maintenance, a provision of the Water Use Act of 1973, may help to insure that existing consumptive use patterns (such as irrigated agriculture) are not restricted in their future development by lack of water and that instream needs are met. Increased storage in the basin could resolve some conflicts over water by making more available when needed. The choice of water-conservative conversion, cooling, and transportation methods for use by the energy industry and better water management by agriculture would reduce water depletion, freeing water for other uses. Complete adjudication of existing rights in the basin will insure the protection of those rights and, at the same time, identify that portion of the basin's water still available for appropriation for consumptive use or for flow maintenance.

The investigation of these and other potential solutions, and recommendations for their implementation, will be the responsibility of the Department of Natural Resources and Conservation, and will be a part of the State Water Plan, now being formulated. Continuing public involvement in the planning process is essential if the DNRC is to prepare a sound, workable water plan that reflects the desires of Montana's citizens. That is the purpose for the public presentation of this report. One way in which the public can help shape the water plan is by expressing their opinions on the controversial issues discussed in this report, such as these:

1) How should Yellowstone Basin water be divided between consumptive (irrigation, municipal, industrial) and nonconsumptive

uses (fish, wildlife, recreation, water quality)?

2) Should some future uses of water be preferred over others?

3) Should the Yellowstone moratorium be extended until the State Water Plan is adopted?

4) How much can the level and quantity of water in each Yellowstone Basin stream be lessened without causing serious impacts on fish and wildlife resources, existing irrigation and municipal diversions, and water quality?

5) In which areas of the basin would the high level of development projected in this report have serious implications?

6) Should industry be required to:

   a) use dry cooling in energy development?

   b) store flood flows for use during critical periods rather than making direct diversions?

   c) use deep ground water when possible?

   d) subsidize other users in water development projects?

7) Should water storage be planned for the Tongue River, Powder River, and Yellowstone mainstem? If so, are offstream sites preferable to those on the main streams?

8) How much and what kind of involvement do citizens and local groups want in the preparation of the State Water Plan for the Yellowstone Basin?

Following consideration of public comment, this report will be revised, reprinted with the addition of recommendations, and distributed to the Montana legislature early in 1977. Please assist in the formulation of those recommendations by filling out the questionnaire attached as the last page of this report and submitting it, along with any other comments, to the DNRC by November 12, 1976.

APPENDIXES

APPENDIX A

CONVERSION TABLES

TABLE A-1

WATER AND COAL REQUIREMENTS FOR COAL PROCESSES

Process	Water	Coal
Thermal-electric generation	15,000 af/y/1,000 mw	4 mmt/1,000 mw
Gasification	9,000 af/y/250 mmcf/d	7.6 mmt/250 mmcf/d
Syncrude	29,000 af/y/100,000 b/d	18 mmt/100,000 b/d
Fertilizer	13,000 af/y/2,300 t/d	3.5 mmt/2,300 t/d
Slurry	750 af/mmt	
Strip Mining	50 af/mmt	

TABLE A-2

WATER UNIT CONVERSIONS

Multiply . . .	By . .	To Obtain . . .
	Flow	
Million gallons per day (mgd)	1.55	cubic feet per second (cfs)
	1,121	acre-feet per year (af/y)
	694	gallons per minute (gpm)
	3.07	acre-feet per day
Cubic feet per second (cfs)	724	acre-feet per year (af/y)
	.646	million gallons per day (mgd)
	Volume	
Acre-feet	326,000	gallons
	43,560	cubic feet
Cubic feet	7.5	gallons

APPENDIX B

MAJOR REQUESTS FOR THE APPROPRIATION OR RESERVATION OF YELLOWSTONE BASIN WATER

This appendix includes three tables. Table B-1 lists major applications for Yellowstone Basin water for industrial use received since the enactment of the 1973 Water Use Act, all of which are affected by the moratorium on Yellowstone water. Table B-2 lists major industrial filings for Yellowstone water for industrial use; these were made before July 1, 1973. Table B-3 includes all applications received as of the publication of this report for the reservation of Yellowstone water for beneficial use.

TABLE B-1

MAJOR INDUSTRIAL APPLICATIONS

Applicant	Source	Appropriation Request	Proposed Uses	Estimated Cost
Utah International, Inc. No. 1004-s42J	Powder River Sec. 31, T. 58 N., R. 75 W. Campbell County, WY	400 cfs and 106,730 acre-feet per year with offstream storage on Fence Creek.	82,705 acre-feet, industrial 2,090 acre-feet, municipal 7,610 acre-feet, irrigation and reclamation 14,325 acre-feet, fish and wildlife	$38 million
Montana Storage Company No. 1205-s42C	Tongue River Sec. 28, T. 1 S., R. 44 E. Rosebud County, MT	675 cfs for pumping to offstream storage of 130,000 acre-feet per year on Lay Creek and 55 cfs up to 40,000 acre-feet per year continuous appropriation throughout the year.	Rent, sale, or distribution for industrial, domestic, wildlife, municipal, agricultural, and recreational uses.	$10.3 million
Water Reserve Company No. 1271-s42C	Tongue River Sec. 18, T. 6 N., R. 48 E. Custer County, MT	500 cfs for pumping to offstream storage on Squaw Creek and Mill Creek for storage of up to 91,000 acre-feet per year and 50 cfs up to 36,200 acre-feet per year continuous appropriation throughout the year.	Rent, sale, or distribution for industrial, agricultural, domestic, municpal, fish and wildlife, and recreational uses.	$12.5 million
Getty Oil Company No. 1391-s42M	Yellowstone River Sec. 35, T. 18 N., R. 56 E. Dawson County, MT	250 cfs for pumping to offstream storage on Thirteenmile Creek for up to 32,000 acre-feet per year [illegible] cfs up to 60,000 acre-feet per year continuous appropriation throughout the year.	Industrial, municipal, irrigation, domestic, recreational, and fish and wildlife uses.	$4 million
Mobil Oil Company No. 5440-s42M	Yellowstone River Sec. 35, T. 19 N., R. 57 E. Richland County, MT	60 cfs continuous diversion up to 35,000 acre-feet per year or 400 cfs peak diversion and 50,000 acre-feet per year to be stored in a reservoir.	Industrial uses for conversion of coal to synthetic fuels and byproducts.	$31.1 million
Intake Water Company No. 3763-s42J	Powder River Sec. 19, T. 9 S., R. 48 E. Powder River County, MT	245,000 acre-feet 35,000 acre-feet 38,700 acre-feet 245,700 acre-feet 564,400 acre-feet per year in a storage reservoir on the mainstem.	Industrial Municipal Irrigation Sediment storage	$35.7 million

TABLE B-1, continued

Applicant	Source	Appropriation Request	Proposed Uses	Estimated Cost
Gulf Mineral Resources No. 4045 - 4058	Yellowstone River and-or Pumpkin Creek, Lignite Creek, and Coal Creek.	Total appropriation for each, all, or a portion of the alternatives presented, not to exceed 90,000 acre-feet per year.	Industrial, municipal, domestic, irrigation, fish and wildlife, and recreation.	
	Sec. 23, T. 8 N., R. 47 E. or Sec. 21, T. 7 N., R. 46 E. or Sec. 23, T. 7 N., R. 46 E. all in Custer County, MT	105 to 210 cfs up to 45,000 acre-feet per year to 90,000 acre-feet per year offstream storage on Pumpkin Creek.	86,310-acre-foot active storage capacity reservoir	
		Offstream storage on Lignite Creek.	50,410-acre-foot active storage capacity reservoir	
		Offstream storage on Coal Creek.	29,240-acre-foot active storage capacity reservoir	
	Ground-water wells (six), 5,000 to 10,000 feet deep.	10 cfs up to 43,444 acre-feet per year.		
	Powder River Sec. 28, T. 3 S., R. 52 E. or Sec. 11, T. 6 S., R. 50 E.	205 cfs up to 45,000 acre-feet per year.		
		Offstream storage on Mizpah Creek Sec. 16, T. 3 N., R. 51 E.	77,525-acre-foot active storage capacity reservoir	
		Offstream storage on Pumpkin Creek Sec. 16, T. 2 N., R. 49 E.	86,310-acre-foot active storage capacity reservoir	
	and-or Pumpkin Creek Sec. 16, T. 3 N., R. 51 E.	18,000 acre-feet per year		
	Mizpah Creek Sec. 16, T. 2 N., R. 49 E.	27,000 acre-feet per year		
				$11.2 million to $50.9 million

TABLE B-2

MAJOR INDUSTRIAL FILINGS FOR APPROPRIATION OF YELLOWSTONE BASIN WATER

Date of Filing	Filed by	County of Application	Source	Amount	Purpose
6/8/73	Intake Water Company	Dawson	Yellowstone River	111.4 cfs (50,000 gpm) up to 80,650 af/y	to be sold, rented, and distributed for irrigation, industrial, municipal, and domestic purposes
12/22/70	Montana Power Company	Rosebud	Yellowstone River	250 cfs continuously	industrial use in a thermal-electric generating plant
4/5/73	Sherman and Stuart Hunt	Rosebud	Yellowstone River	200 cfs	irrigation, stockwater, domestic, and industrial purposes
9/6/50	Montana Power Company	Yellowstone	Yellowstone River	200 cfs	industrial use in a thermal-electric generating plant
4/5/66	Montana Power Company	Yellowstone	Yellowstone River	200 cfs	industrial use in a thermal-electric generating plant
6/29/73	Basin Electric Power Cooperative	Rosebud	Yellowstone River	50 cfs	industrial use in a thermal-electric generating plant

TABLE B-3

APPLICATIONS RECEIVED FOR THE RESERVATION OF YELLOWSTONE BASIN WATER

Date Received	Application No.	Applicant	Source	Amount
3/15/74	1781-r	Montana Fish and Game Commission	Mainstem of Yellowstone River	Instream flow request for the Yellowstone River

Month	Mouth of Clarks Fork Yellowstone River to Mouth of Bighorn River acre-feet	cfs	Mouth of Bighorn River to Mouth of Powder River acre-feet	cfs	Mouth of Powder River to State Line acre-feet	cfs
January	135,275	2,000	245,955	4,000	276,705	4,500
February	122,185	2,200	222,150	4,000	305,470	5,500
March	159,870	2,600	387,380	6,300	461,175	7,500
April	178,515	3,000	374,880	6,300	446,325	7,500
May 1-20	238,020	6,000	364,965	9,200	416,535	10,000
May 21-31	250,915	11,500	370,915	17,000	436,370	20,000
June	1,207,950	20,300	1,785,150	30,000	2,023,340	34,000
July 1-20	456,205	11,500	674,390	17,000	833,020	20,000
July 21-31	130,910	6,000	200,730	9,200	218,200	10,000
August	233,655	3,800	332,040	5,400	368,930	6,000
September	178,515	3,000	321,330	5,400	327,305	5,500
October	184,465	3,000	368,930	6,000	368,930	6,000
November	178,515	3,000	357,030	6,000	357,030	6,000
December	135,275	2,200	245,955	4,000	276,705	4,500
TOTAL	3,790,270		6,251,800		7,116,040	

8/21.74	6294-r42M	Buffalo Rapids Irrigation Project	Yellowstone River	167 cfs up to 124,400 acre-feet per annum
5/28/76	8476-r43BJ	City of Big Timber	Yellowstone River	6.19 cfs up to 4,483 acre-feet per annum
9/8/76	9442-r43Q	Huntley Project	Yellowstone River	92 cfs up to 27,372.3 acre-feet per annum
9/28/76	9646-r43Q	City of Billings	Yellowstone River	1190 cfs up to 317,456 acre-feet per annum

APPENDIX C

METHODOLOGY OF THE IRRIGATION FEASIBILITY STUDY

Irrigation costs were separated into water delivery costs and application costs. Annual costs of delivering water to the farm gate were developed for each lift and length category. Basic data were provided by the U.S. Bureau of Reclamation, and a computer program was used to select the most efficient pump and pipe size for each category, based on both initial and annual operation costs.

Water application costs were developed from information provided by the Cooperative Extension Service (1969). The costs of a center-pivot sprinkler system were used, since this type was used on over half of all new irrigation systems installed since 1973 (Montana DNRC 1975b).

Costs for both the water delivery system and the application system include both initial costs and annual operation costs. The initial cost of all pumps, pipe, houses, electrical equipment, and installation was converted to an annual cost using a capital recovery factor (CRF) at 10% interest with a 10-year loan period, terms slightly better than the prevalent rate and loan period at the time the study was begun. This amortized cost was then added to the annual operation costs (labor, maintenance, repairs, and electricity) and divided by the irrigated acres to determine total irrigation costs per acre per year.

Farm budgets were used to compute the per-acre capacity to pay all irrigation costs. Separate farm budgets were prepared for each subbasin to reflect local farming practices. All crops produced in each area were placed into four categories and an average cropping pattern developed to represent the historical patterns. Sugar beets were used to represent all high-value cash crops such as beets or dry beans. Barley represents the grains; alfalfa represents all hay crops; and corn silage represents all silage crops including ensiled hay or beet tops.

The farm budgets compute the costs and profits associated with crop production, plus generalized farm costs such as investment, maintenance, and repair of buildings and fences. Since the budgets include all costs associated with a farm enterprise, including adequate payments to the farmer for his labor, management, and investment, all remaining profit may be used to pay irrigation costs. This profit margin was then compared to the total irrigation costs for each lift and length category. Maximum pumping lifts and distances were identified for each subbasin, and the total acreage feasible to irrigate was determined.

APPENDIX D

MUNICIPAL WATER USE IN THE YELLOWSTONE BASIN

One conclusion of this report was that, of the three main consumptive water uses in the Yellowstone Basin (energy, irrigation, and municipal), municipal water use would be by far the least demanding on the basin's water resources in the future. Depletion for municipal use projected in the three levels of development presented here would range from 5,880 af/y for the low projection in 2000 to 10,620 af/y for the high, compared with from 158,340 af/y to 474,960 af/y for irrigation and from 48,350 af/y to 321,190 af/y for energy water use. This appendix includes data on 1970 municipal water use in the Yellowstone Basin (table D-1), population simulations for the year 2000 (table D-2) used in projecting future municipal use, and the projected increases in depletion for municipal use in 2000, by subbasin (table D-3).

TABLE D-1

MUNICIPAL WATER USE IN THE YELLOWSTONE BASIN
in 1970

County	Number of Cities having Municipal Systems	Population Served	Water Use in mgd			Per Capita Water use, in gpcd
			Ground Water	Surface Water	Total	
Big Horn	6	5,089	.235	.791	1.026	201
Carbon	6	3,592	.512	.679	1.191	332
Custer	1	9,070	.390	1.558	1.948	215
Dawson	3	8,244	.489	.991	1.480	179
Park	6	8,017	.361	1.766	2.127	265
Powder River	2	.,099	.146	0	.146	132
Prairie	0	0			0	
Richland	2	5,499	1.223	0	1.223	222
Rosebud	5	5,353	.671	.333	1.004	187
Stillwater	3	1,845	.634	0	.634	343
Sweet Grass	1	1,592	.885	0	.855	537
Treasure	1	373	.125	0	.125	335
Yellowstone	5	86,749	.175	16.976	17.151	198
TOTAL	38	136,522	5.816	23.094	28.910	
AVERAGE						212

TABLE D-2

YELLOWSTONE BASIN POPULATION SIMULATIONS FOR 2000

City	Population*	Population Simulations for 2000		
		Low Level of Development	Intermediate Level of Development	High Level of Development
Ashland	531	2,379	3,423	7,236
Billings	63,729	94,999	95,523	98,294
Birney	13	60	70	137
Broadus	799	4,138	6,096	10,692
Busby**	300	1,160	1,038	2,036
Colstrip	200	5,044	5,824	15,107
Forsyth	1,873	5,189	5,664	10,249
Glendive**	6,441	8,341	8,341	8,713
Hardin	2,733	4,783	5,458	7,094
Lame Deer**	650	1,062	1,012	1,442
Lodge Grass	806	1,090	1,215	1,462
Miles City	9,023	15,890	16,461	20,254
Sidney**	4,551	6,032	6,032	6,404

SOURCE: Prepared by the Montana Department of Community Affairs for the Yellowstone Impact Study.

*Populations given are the most recent available census or estimate. In Ashland, Birney, Busby, Colstrip and Lame Deer, the 1970 census population is given; all others are 1975 censuses or estimates.

**In Busby and Lame Deer, the projected population is less in the intermediate level of development than in the low; in Glendive and Sidney, it remains constant. The overall basin population increases from the low to the intermediate level of development, but, because the locations of coal development change, the projected population shifts from one area to another.

TABLE D-3

THE INCREASE IN WATER DEPLETION FOR MUNICIPAL USE IN 2000 BY SUBBASIN

Subbasin	Population Increase	Increase in Depletion (AF)
LOW LEVEL OF DEVELOPMENT		
Upper Yellowstone	0	0
Clarks Fork	0	0
Billings Area	31,270	3,480
Bighorn	2,050	negligible
Mid-Yellowstone	15,030	1,680
Tongue	1,788	negligible
Kinsey Area	0	0
Powder	3,339	360
Lower Yellowstone	3,381	360
Total	56,858	5,880
INTERMEDIATE LEVEL OF DEVELOPMENT		
Upper Yellowstone	0	0
Clarks Fork	0	0
Billings Area	31,804	3,540
Bighorn	2,755	300
Mid-Yellowstone	16,800	1,860
Tongue	2,900	300
Kinsey Area	0	0
Powder	5,300	600
Lower Yellowstone	3,381	360
Total	62,940	6,960
HIGH LEVEL OF DEVELOPMENT		
Upper Yellowstone	0	0
Clarks Fork	0	0
Billings Area	34,565	3,900
Bighorn	4,361	480
Mid-Yellowstone	34,494	3,840
Tongue	6,705	780
Kinsey Area	0	0
Powder	9,900	1,140
Lower Yellowstone	4,125	480
Total	94,150	10,620

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YOUR RESPONSE TO WHICH WAY? THE FUTURE OF YELLOWSTONE WATER

The purpose of this informal questionnaire is to solicit your opinion on the issues discussed in this draft version of Which Way? The Future of Yellowstone Water to assist the Montana DNRC in preparation of recommendations to the next Montana legislature. It is important that we know what you think; our recommendations must reflect public opinion. Remember, there is no right or wrong answer; respond to each question according to how you feel about it. If you have no opinion on some question, do not answer it. If you would like to make additional comments, please attach them on a separate sheet. All responses will be confidential.

I

	Yes	No
1. Regarding water rights in the basin:		
a) Should the Yellowstone Moratorium on large appropriations of water, which will expire in March of 1977, be extended until the State Water Plan is adopted?	___	___
b) Should more tax money be expended to speed up the process of adjudicating water rights?	___	___
c) Should more tax money be expended to assist local governments in applying for water reservations and in refining plans after reservations are granted?	___	___
d) Should the state of Montana establish a legal defense fund to be used for the protection of existing and future water rights?	___	___
2. Before additional water is appropriated for consumptive use, should some level of instream flow be guaranteed to maintain fish and wildlife habitat, water quality, and recreation?	___	___

3. Identify the projected level of development (as presented in the report) that you would find acceptable:

	Energy			Irrigation		
	High	Intermediate	Low	High	Intermediate	Low
a) in your subbasin?	___	___	___	___	___	___
b) in the entire Yellowstone Basin?	___	___	___	___	___	___

4. In the future, should some uses of water be preferred over others? If so, how, on a numerical scale using 1 to indicate first preference, 2 to indicate second preference, and so on, would you rate each of the following water uses?	___	___

_____ energy
_____ agriculture
_____ municipal
_____ domestic
_____ recreation
_____ fish and wildlife
_____ maintenance of water quality

	Yes	No
5. Should the Yellowstone mainstem be protected from the construction of large dams?	___	___
6. Should water be taken out of the Yellowstone mainstem to supply energy development in the Tongue and Powder subbasins?	___	___
7. Should water storage projects be constructed on these rivers:		
a) Tongue River?	___	___
If "yes", do you prefer offstream ____ or onstream ____		
b) Powder River?	___	___
If "yes": offstream ____ or onstream ____		
c) Yellowstone River?	___	___
If "yes": offstream ____ or onstream ____		
Generally, should funding and construction of proposed water storage projects be federal _____, state _____, or private _____? (check one)		
8. Should industry be required to:		
a) use dry cooling in energy development?	___	___
b) store flood flows for use during critical low-flow periods rather than making year-round direct diversions?	___	___
c) use deep ground water when possible?	___	___
d) subsidize other users in its water development projects?	___	___
9. Would the impacts on fish and wildlife, water quality, and recreation associated with the high level of development be acceptable to you?	___	___
10. Do you think that there are major water-related matters in the Yellowstone Basin which were not satisfactorily addressed in this report?	___	___

If so, what are they? _____

_____

11. How can the DNRC better involve the public in formulating the State Water Plan? _____

_____

II

12. Are you a city/town_____ or rural _____ resident? (check one)
If the former, indicate size of city: less than 2500 _____
more than 2500 _____

13. In which county do you live? _____
In which of the subbasins identified in this report?

_____

14. Occupation _____
Organization or agency that you represent _____

_____

This page will be detached by the Department to maintain confidentiality in the questionnaire response.

III

	Yes	No
16. a) Would you like to be involved in the water planning process for the Yellowstone Basin?	___	___
b) If "yes," would you like to participate on a basin-wide or area-wide study and planning team?	___	___

In what capacity?

advisory committee _____
technical committee ____
review and comment _____
other (explain) _____

_____
_____
_____

17. Would you like to be on a mailing list to receive information relative to water planning in the Yellowstone?	___	___
18. Would you like to receive a summary of the response to this questionnaire?	___	___

If your answer to any question in Part III is "yes," please print your name and address below.

_____

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